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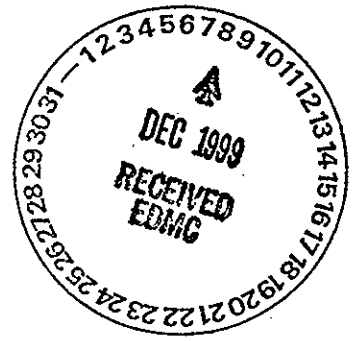
Rev. 0

1999 Environmental Restoration Contractor Revegetation Monitoring Report



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Rev. 0

1999 Environmental Restoration Contractor Revegetation Monitoring Report

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EXECUTIVE SUMMARY

This report documents the results of revegetation monitoring conducted in early May through early July 1999. Fourth-year monitoring was conducted at the Horn Rapids Landfill, Horseshoe Landfill, and Nike Landfill. Third-year monitoring was conducted on the Bridge Overlook, PSN 72/82, PSN 12/14, and the North Slope Cheatgrass Area. Second-year monitoring was conducted at the 600-104 waste site (2,4-D cleanup site); the 300-FF-1 sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) transplant areas, 216-A-25 emergency extension site; and the 200-ZP-1 pipeline. First-year monitoring was conducted at the 300 Area North Process Trench, Environmental Restoration Disposal Facility (ERDF) Mitigation sites, and the 116-C-1 Restoration site.

The Horseshoe Landfill was revegetated with transplanted bunchgrasses and the Nike landfill sites were revegetated with sagebrush tubelings and transplanted bunchgrasses. The presence of numerous native bunchgrasses and the dense sagebrush cover on the Horseshoe Landfill demonstrates that a diverse native plant community has developed and should continue into late seral conditions. The canopy cover of volunteer sagebrush plants on Horseshoe Landfill has increased to 19.1% from 14.4% in 1998, and 5.5% in 1997. Bunchgrasses are also increasing in dominance through recruitment of seedlings. Bluebunch wheatgrass (*Agropyron spicatum*) increased from 3.4% in 1998 to 8.5% cover in 1999. However, cheatgrass (*Bromus tectorum*) remains as the dominant grass species on the landfill with 49.6% cover. A total of 29 species were observed on the landfill, 13 of which were native and recorded in the plot-frames with an additional 6 native species observed on the site but not counted in a plot-frame. Conversely, 21 species were observed on the reference site with 15 being native species.

The Horn Rapids Landfill was revegetated with crested wheatgrass (*Agropyron cristatum*) and Siberian wheatgrass (*Agropyron sibericum*) during the fall of 1995. Canopy cover of wheatgrasses has changed very little from 1998 measurements with cover ranging from 19 to 32% among plots. Frequency of occurrence for wheatgrasses was very similar across the 6 plots ranging from 80 to 96%. Cheatgrass appears to be slightly higher on most plots this year with the exception of plot 6, which has decreased by 15% from last year. Russian thistle (*Salsola*

kali) presence is nominal, averaging 0.1%, making this plant no longer a significant component to this vegetative community.

The vegetation recovery at the Bridge Overlook and PSN 72/82 continues to look promising. The 1995 revegetation effort used salvaged plants from the ERDF. The 1999 measurements identified five new plant species on the waste site. Canopy cover for cheatgrass decreased by 6.6% and 29.6% on the Bridge Overlook waste site and its reference site, respectively. Cryptobiotic crust continues to develop on the waste site and has reached 5.6% cover indicating the continuing recovery of the soil. On the PSN 72/82 Well Mound site, 21 plant species were identified, 15 of which were native. Shrub cover and frequency of big sagebrush and gray rabbitbrush (*Chrysothamnus nauseosus*) changed only slightly from 1998 and for the first time, all four of the transplanted bunchgrass species were observed on the waste site. Cryptobiotic crust on the waste site has significantly increased from last year (0.6% to 19.8% cover). All the planted species except spring turpentine parsley (*Cymopterus terebinthinus*) were identified on the small staging area adjacent to the Well Mound site. In addition to the planted species, the small staging area is also being colonized by many native species including six-weeks fescue (*Festuca octoflora*), annual phlox (*Microsteris gracilis*), spring whitlow (*Draba verna*), tansy mustard (*Descurainia spp*), hoary aster (*Machaeranthera canescens*), and matted cryptantha (*Cryptantha circumscissa*).

At PSN 12/14, seven plots were planted in 1995 with sagebrush tubelings and salvaged bunchgrasses while the access road was seeded with a mixture of sagebrush, bitterbrush, snow buckwheat (*Eriogonum niveum*), spring turpentine parsley, Carey's balsamroot (*Balsamorhiza careyana*), and Sandberg's bluegrass (*Poa sandbergii*) in 1996. Twenty plant species were identified on the access road, 15 of which were native species. New native species colonizing the road include tansymustard, yarrow (*Achillea millefolium*), buckwheat milkvetch (*Astragalus caricinus*), and winged dock (*Rumex venosus*). On the waste sites, all plots were still dominated by cheatgrass. However, Russian thistle canopy coverage has remained low on all plots except plot 2, which has increased from 0.5 to 10% cover. Plot five had the highest cover and frequency of native bunchgrasses with significant recruitment. The survival of the transplanted

bunchgrasses on plots 2, 4, 5, 6, and 7 ranged from 46.2% on plot 4 to 80.9% on plot 5, with an average survival for all plots of 64.7%.

Sagebrush seedlings were planted along an access road in August and October 1996 in a burned area on the Saddle Mountain Wildlife Refuge (North Slope Cheatgrass Area). Survival of the sagebrush transplanted in August was very low due to high temperatures, injured root systems, and low soil moistures. As a result, survivorship of the August planting is no longer measured. However, the sagebrush planted in October had an average survival of 76.7% after 3 years.

Revegetation of the waste sites 600-104, 216-A-25 emergency extension, 300-FF-1, and the 200-ZP-1 pipeline was conducted in the early fall of 1997 and late winter of 1998. All seeds and plants were derived from species on the Hanford Site. Seeding was conducted on the 600-104 site after bioremediation of 2,4-D contaminated soils. Thirty-two species were observed this year, of which 25 were native. The dominant species, as expected were Russian thistle and cheatgrass. Sagebrush planted at the 216-A-25 emergency extension site had a survival of 65%. Survivorship was difficult to determine due to the height of the cheatgrass. As a result, only the sagebrush planted in groups of three and marked with pin-flags could be counted. On June 22, 1999, survivorship of sagebrush at 300-FF-1 was determined to be 54%. The planting of sagebrush tubelings at the 200-ZP-1 pipeline was not as successful as expected, having only 29% survivorship; however, the site is surrounded with mature sagebrush and recruitment of seedlings is expected.

The 300 Area Process Trench was remediated in mid-1997 through early 1998. A majority of the trench was regraded and contoured with the surrounding soils; then in the fall of 1998, the site was broadcast seeded with 50 kg per hectare of crested wheatgrass. Straw was applied as a mulch and crimped into the soil. Initial vegetation analysis was conducted on July 1, 1999, finding 21 plant species observed on the site, 13 of which were native. The most abundant species was domestic wheat (*Triticum spp*), as a volunteer species from the straw mulch. The wheat will disappear from the site as other species become more dominant. Frequency of crested wheatgrass is high at 80%, indicating successful germination.

In November 1998, 73,800 sagebrush seedlings were planted in shrubless areas on the Arid Lands Ecology Reserve (ALE) as mitigation for habitat lost during expansion of ERDF. Five areas on ALE were selected for revegetation and habitat enhancement. Sagebrush survival was assessed in February and March of 1999 to get an initial estimate of survival before the stresses of summer drought. Survival ranged from lowest on area 5 with 57.8% to highest in area 2 with 97.8% survival, having an overall survival across the plots of 80.8%.

The 116-C-1 Process Trench revegetation was done as a demonstration project to evaluate practical methods for revegetating remediated sites with native species. Backfill material representative of naturally occurring soils in the area served as the planting medium for two of four treatments. The other two used topsoil retrieved from ERDF during excavations. In November 1998, a native seed mix was planted to the entire area. Cryptogamic soil/dust was also applied to the east half of the area to inoculate the soil surface and wheat straw mulch was applied to the entire area then crimped. Sagebrush tubelings were planted throughout the site in groups of three. Irrigation was applied to one half the backfill substrate and one half of the topsoil substrate. Analysis in June 1999, found 24 plant species on the 116-C-1 site, 16 of which were native including all 7 native species planted. Species count was highest on the topsoil treatment areas, with 21 on the nonirrigated site and 16 on the irrigated site. Sagebrush survival varied, ranging from 79% on the irrigated topsoil to 100% on the nonirrigated backfill. The majority of the sagebrush mortality was from the deer uprooting the tubelings in the topsoil area.

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APPENDICES

CONTENTS (cont.)

FIGURES

TABLES

METRIC CONVERSION CHART

The following conversion chart is provided to aid the reader in conversion.

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit

1.0 INTRODUCTION

This report documents the results of revegetation monitoring conducted in 1999. The monitoring sites included the Horseshoe and Nike Landfills on the Arid Lands Ecology Reserve (ALE) and the Horn Rapids Landfill (HRL) near the City of Richland. Waste sites on the Hanford North Slope included the former Army sites titled Bridge Overlook, PSN 72/82, and PSN 12/14, as well as the 600-104 (2,4-D) cleanup site. Other sites include the 300-FF-1 mitigation and revegetation areas; the 216-A-25 emergency extension site; the 200-ZP-1 pipeline; and the 116-C-1 restoration site. Sagebrush survival was monitored at the North Slope Cheatgrass Area and at several revegetation sites on the ALE collectively called the Environmental Restoration Disposal Facility (ERDF) compensatory mitigation sites. Figure 1 shows the locations of these sites.

The extent of the revegetation effort conducted at each monitoring site varied depending upon the surrounding habitat, existing conditions, and the future use of the site. The purpose of the revegetation monitoring is to measure the progress of plant succession, and in most cases, compare it to the surrounding undisturbed plant community. Each site will be discussed separately along with a brief description of the revegetation effort and the results of the 1999 monitoring.

This report provides the fourth year measurements at the Horseshoe Landfill, Nike Landfill, and HRL. Results from the previous year's measurements are documented in Kemp et al. (1998), Gano et al. (1997), and the 1996 measurements were provided in a letter report by Henckel (1996). The measurement data from these previous reports are provided in Appendices A, B, and C of this report. A comparison of the vegetation changes over the previous years is provided in this document.

This is the third year that measurements have been taken at the Bridge Overlook, PSN 72/82, PSN 12/14, and the North Slope Cheatgrass Area. Revegetation at these sites, except for the Cheatgrass Area, began in the spring of 1995 with the salvage and transplanting of bunchgrasses from the Hanford Site. In 1996, supplemental plantings using locally collected seed were conducted at the PSN 12/14 access road and at the PSN 72/82 sites. The Cheatgrass Area was planted with salvaged sagebrush seedlings in August and October 1996. Second year measurements are provided for the 600-104 (2,4-D) waste site, 216-A-25 emergency extension site, the 300-FF-1 remedial action site, and the 200-ZP-1 pipeline. First year measurements are provided for the 300-FF-1 North Process Trench and the 116-C-1 restoration site. Initial monitoring is also provided of sagebrush survival at the ERDF compensatory mitigation sites on the ALE.

1.1 METHODS USED IN EVALUATING VEGETATION RECOVERY

The vegetation monitoring consisted of measuring the canopy cover of all plant species found at a site, the frequency of occurrence, and the survival of transplanted bunchgrasses and sagebrush. All values were then converted to percentages. Canopy cover and frequency measurements were conducted using the methods of Daubenmire (1970). Canopy coverage is defined in Daubenmire (1970) as "the percentage of ground surface included in the vertical projection of a

polygon drawn around the extremities of undisturbed foliage of a plant." This method can provide a measure of the amount of ground covered by each species. Since it is possible, in dense stands of vegetation, to have species overlapping each other, total measured vegetative cover can exceed 100%. Within each location, a series of plot-frames were analyzed for canopy coverage of each species present. Frequency is represented as the percentage of occurrences that a species is observed in the number of plot-frames measured. For example, if a species was represented in 10 out of 25 plot-frames, its frequency would be 10/25 x 100 = 40%.

The relative magnitude of a frequency rating, when compared to a canopy coverage rating, provides an index of distribution of a species and its influence within a vegetative stand. At sites where bunchgrasses and/or sagebrush were transplanted, the survival (if it could still be determined in 1999) was measured by counting a representative number of plants at the site, determining if they were dead or alive, and calculating the percent alive.

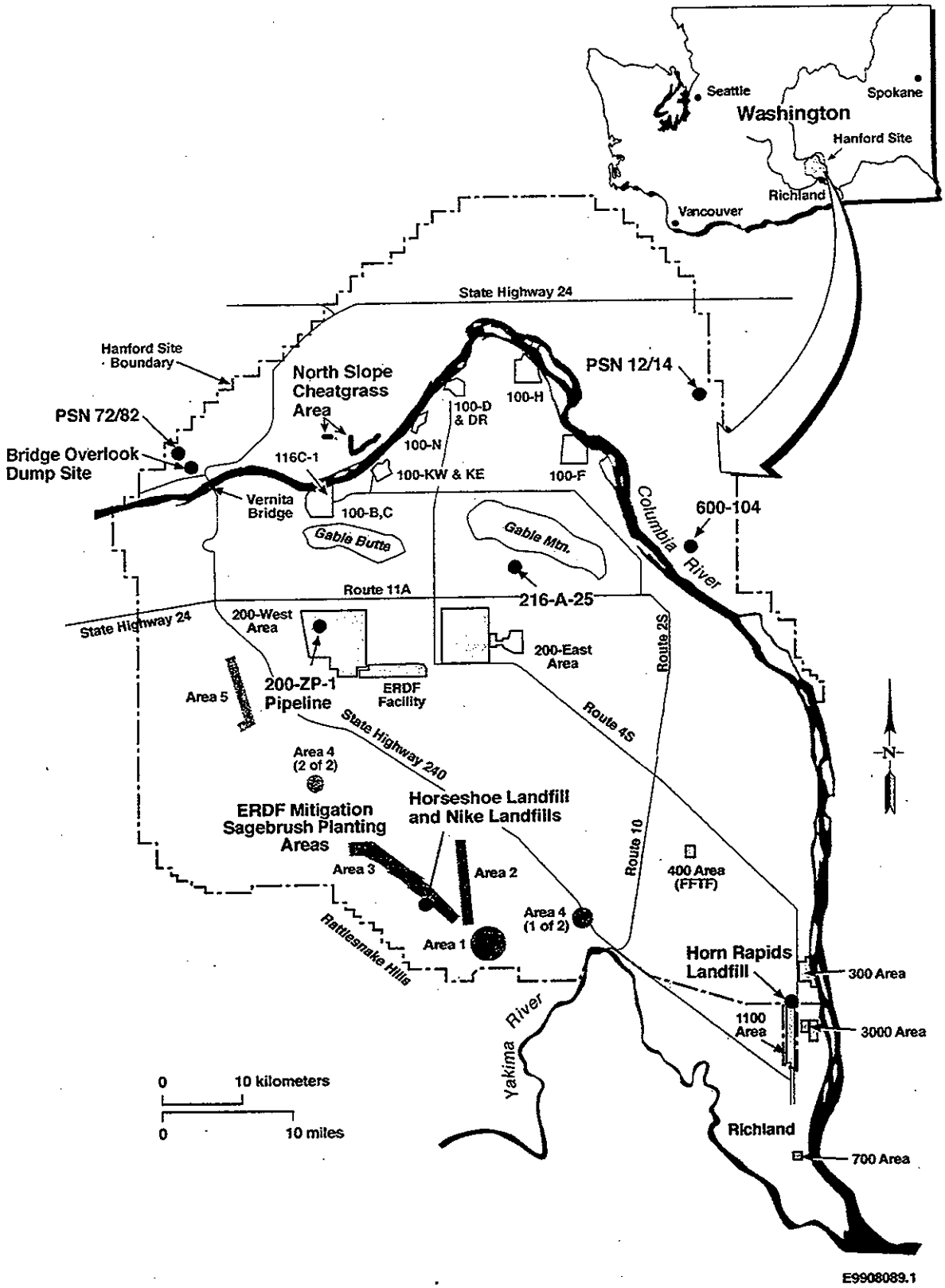
This report uses taxonomic nomenclature from Hitchcock and Cronquist (1973). Some plant taxonomic names have been updated and the revised names are provided in Appendix D.

The objective of all revegetation efforts is guided by the type of restoration that is conducted, as well as the criteria that is used to assess the success of the effort. At the Horn Rapids Landfill (HRL), the objective was to stabilize the topsoil and protect the landfill cap, while at the Horseshoe and Nike landfills, the objective was to restore the areas with native bunchgrasses to suppress the growth of exotic plant species such as cheatgrass. All of the North Slope revegetation sites are surrounded by high-quality habitat; thus, the objective was to restore those sites to blend with the adjacent plant community. The objective of revegetating the North Slope Cheatgrass Area was to promote sagebrush reestablishment in a previously burned area. The objective at 600-104, 216-A-25, and 200-ZP-1 pipeline sites was to stabilize the soils and provide onsite rectification for lost sagebrush habitat. The objective at the 300-FF-1 sagebrush site was to compensate for the loss of shrubs during remediation of the 618-4 burial ground.

Reference sites were established for the Horseshoe Landfill and the North Slope sites. Reference sites were selected because they had physical and biological components that were similar to the pre-waste site areas. For this monitoring effort, the reference sites served to identify the plant composition of the surrounding area that was then used to compare the plant establishment of the revegetated area. In some cases, such as the 300-FF-1 sagebrush site, reference sites were not used because sagebrush was planted into an area with late successional perennial grass and forb understory for the purpose of reestablishing the shrub component.

Success criteria are often different for each waste site due to different objectives of each revegetation effort. However, all sites will be evaluated based upon plant canopy cover, plant community composition, and survival and growth of transplants. These criteria are detailed in the *Revegetation Manual for the Environmental Restoration Contractor* (McLendon and Redente 1997). Revegetation efforts will be considered successful if the areas are stabilized to prevent erosion and dominated by recovering stands of native sagebrush, bunchgrasses, and other native species.

Figure 1. Hanford Site Showing Locations of Revegetation Areas.



2.0 HORN RAPIDS LANDFILL

The HRL is a 20-hectare area located in the 1100-EM-1 Operable Unit immediately north of Richland, Washington. The landfill was used primarily to dispose of office and construction waste, asbestos, sewage sludge, and fly ash. The remedial investigation/feasibility study for the 1100-EM-1 Operable Unit (DOE-RL 1992) identified about 230 m^3 of polychlorinated biphenyl (PCB)-contaminated soil in the landfill. The remedial action, documented in the 1100 Area Record of Decision (ROD) (EPA 1993), included excavation of the PCB-contaminated soil and capping 10.3 hectare of the landfill. The landfill cap consisted of a 0.5-m layer of gravel covered with 15.2 cm of topsoil. The objective of this revegetation project was to stabilize the topsoil and protect the landfill cap. The site was revegetated with crested wheatgrass and Siberian wheatgrass in the fall of 1995 with guidance and concurrence from the Hanford Natural Resource Trustee Council.

A secondary goal of the revegetation effort was to compare planting techniques using a traditional rangeland seed drill and a planting device called an Imprinter. The Imprinter has been successfully used for planting in arid climates (St. John and Dixon 1995). A special imprinter was used at the HRL that had an added capability to inoculate the soil with mycorrhizal fungi. Mycorrhizal fungi form a beneficial symbiotic relationship with the roots of many late seral plants, including bunchgrasses. The fungus absorbs nutrients from the soil and passes them to the plant in exchange for sugars from the plant. This relationship is not usually formed with the early seral stage weedy plant species.

2.1 REVEGETATION PLAN

Five different planting treatments were evaluated to determine the best technique and provide information that will be useful in planning future restoration projects. The area of the landfill that was revegetated was divided into six roughly equal plots for the purpose of establishing treatment areas (Figure 2). Two treatments using a rangeland seed drill were established. The first treatment included planting seed with a fertilizer application rate of 22.5 kg of nitrogen/ hectare and mulching the area with wheat straw (plots 1 and 6). This method has been used many times on the Hanford Site and has proven successful with this seed mix. The second treatment using the rangeland drill (plot two) applied seed and straw mulch without fertilizer.

Three treatments were used to test the efficacy of the Imprinter under these conditions. The first was the application of seed, mycorrhizal fungi, and wheat straw mulch (plot 3). The second was the application of seed and mycorrhizal fungi with no mulch (plot 4) and the third was the application of seed alone (plot 5). The application of straw mulch was intended to reduce wind erosion and increase soil moisture retention. The mulch may also serve an added function to tie-up excess available soil nitrogen that reduces competitiveness of early successional weedy species (Klein et al. 1996). Straw was spread over the appropriate treatment areas at a rate of 4.5 metric tons per hectare.

The target seeding rate was 16.8 kg/hectare pure live seed on all treatments with a 50% mix of both species. The actual seeding rate varied between the Imprinter and the range drill because of the difference in the metering systems on the two pieces of machinery. The three plots planted

with the range drill (plots 1, 2, and 6) and plots 3 and 5 planted with the Imprinter received similar rates of seed. However, plot 4 was the first to be planted and received a higher seeding rate because the metering system was not initially calibrated to the proper rate.

2.2 MONITORING RESULTS

The vegetation on the HRL was measured on May 11, 1999 by estimating canopy coverage and frequency of occurrence. Twenty-five plot frames measuring 20 by 50 cm were analyzed for each treatment. This year, 30 species were recorded on the HRL, an increase from 28 in 1998, 20 in 1997, and 10 from 1996. The species with the most canopy cover and frequency of occurrence this year were wheatgrasses (*Agropyron spp*), cheatgrass, jagged chickweed (*Holosteum umbellatum*), and spring whitlow. Jagged chickweed and spring whitlow are small (usually less than 5 cm tall) winter annual plants that are very common early successional species.

Canopy cover for wheatgrasses has changed very little since 1998, ranging from 19 to 32% among plots (Table 1). The largest change occurred on plot 2, increasing from 24% in 1998 to 31.8% in 1999. Changes on the other plots are minimal and within the expected fluctuations using these methods. The frequency of occurrence for the wheatgrasses was very similar across the 6 plots ranging from 80 to 96% (Table 2). It appears that regardless of the planting technique used, the canopy cover is leveling out across the plots and is now comparable to a mature stand of wheatgrass. For comparison, the canopy cover of a mature stand of Siberian wheatgrass/ thickspike wheatgrass (*Agropyron dasytachyum*) that was planted on the 216-T-35 burial ground of the Hanford Site was measured at 18.3% after more than 10 years of growth (WHC 1994). However, HRL has a higher density of smaller plants than a mature stand of wheatgrass. The density and stature of the plants is expected to continue changing; however, since the soils are similar and all plots are exposed to the same weather conditions, the canopy cover and frequency of occurrence is expected to remain comparable across the plots.

Cheatgrass appears to be slightly higher on some plots this year. On plot 6, cheatgrass canopy cover decreased by 15% from last year. Russian thistle continues to be present but the canopy cover is extremely small, averaging 0.1%, making this plant no longer a significant component of this community. Most other species occur in low numbers and are expected to maintain a low occurrence due to the dominance of the wheatgrasses and the cheatgrass. The measurements of "bare soil and litter" are a reflection of the amount of biomass being produced on this site. The percent of bare soil has decreased significantly this year while the percent of litter has increased. The differences in bare soil from 1998 to 1999 range from 18 to 43% less while the increases in litter range from 7 to 29%.

Again, several species were observed on the landfill that did not occur in an individual plot frame. These occurrences represent the pioneering of plants from the surrounding community. Some plants will continue to increase their presence, while others remain at a low level or even disappear as succession progresses. Gray rabbitbrush, in particular, is expected to increase its presence. It was recorded in a plot-frame on plot 2 and observed in plots 3, 4, 5, and 6. The noxious weeds rush-skeletonweed (*Chondrilla juncea*), whitetop (*Cardaria draba*), and diffuse knapweed (*Centaurea diffusa*) were also observed in some of the plots and uprooted. Their

presence is still very low on the site; however, if their populations increase, control measures will be considered.

Trends in canopy cover were examined over a duration of 4 years for three species at the Horn Rapids Landfill. Species examined were Russian thistle, cheatgrass, and wheatgrasses. Between 1996 and 1999, Russian thistle declined in abundance from 12.7% to 0.1% cover, which is due to increased competition by other species (Figure 4). The number of species observed on Horn Rapids Landfill increased from 10 in 1996 to 30 species in 1999. This trend is typical in the early stages of plant succession on disturbed soils.

Cheatgrass showed an overall increase in abundance from 1996 to 1998, rising from 1.3% cover in 1996 to 19.9% in 1998. While this increase appeared to be dramatic, 1999 canopy cover data indicates the population may be stabilizing around 20% cover (Figure 4).

Representation of wheatgrasses at the Horn Rapids Landfill showed variation between 1996 and 1999. An inflated seeding rate during planting in 1995 resulted in good production of wheatgrass in 1996 (12.7% cover), followed by a subsequent decrease in abundance (9.35% cover in 1997), most likely due to crowding and self thinning. By 1998, canopy coverage by wheatgrass had recovered and risen by 23%. The wheatgrass population at Horn Rapids Landfill site appears to be stabilizing with only a 1% increase in cover between 1998 and 1999 (Figure 4).

Figure 2. Horn Rapids Landfill Showing Six Treatments.

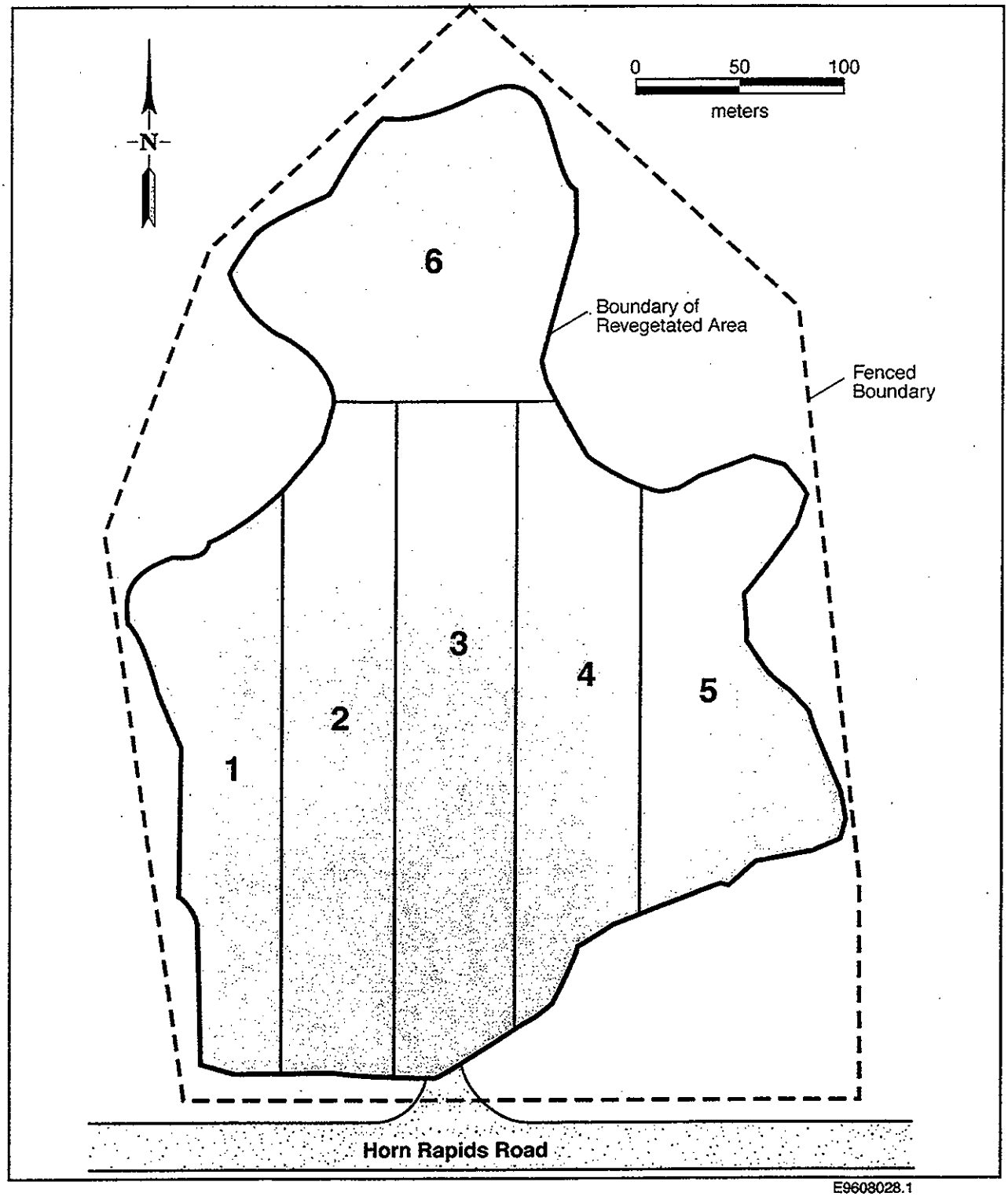


Table 1. Percent Canopy Cover on Horn Rapids Landfill for 1999.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
*Agropyron spp** (wheatgrasses)	22.1	31.8	19	22.4	19.1	29.8
*Salsola kali** (Russian thistle)	0.1	0.1	0.1	0.1	0.01	0.1
*Bromus tectorum** (cheatgrass)	30.3	18.4	30.1	11.5	14.5	20.1
Amsinckia lycopsoides (tarweed fiddleneck)	0.7	X	X	X	--	0.1
*Sisymbrium altissimum** (tumblemustard)	--	X	0.1	0.1	X	--
Ambrosia acanthicarpa (bur ragweed)	0.2	0.1	--	--	0.1	0.2
*Convolvulus arvensis** (field bindweed)	X	X	X	X	X	X
*Holosteum umbellatum** (jagged chickweed)	21.4	24.5	25	18.5	12.8	20.4
*Lactuca serriola** (prickly lettuce)	X	--	--	--	--	--
Draba verna (spring whitlow)	7.3	9.7	13.6	16	6.4	4.5
Descurainia pinnata (tansymustard)	0.1	--	--	--	X	--
Epilobium paniculatum (tall willowherb)	0.1	--	0.2	--	--	--
Poa sandbergii (Sandberg's bluegrass)	X	--	2.1	--	X	X
Plantago patagonica (Indian wheat)	--	--	--	--	--	0.1
*Erodium cicutarium** (storksbill)	0.1	--	0.2	X	0.1	--
*Tragopogon dubius** (yellow salsify)	X	0.1	X	--	--	X
Agoseris grandiflora (mountain dandelion)	--	--	X	--	--	--
Eriogonum niveum (snow buckwheat)	X	X	X	--	--	X
Astragalus caricinus (buckwheat milkvetch)	--	--	X	--	--	--
Machaeranthera canescens (hoary aster)	X	X	--	X	--	X
Achillea millefolium (yarrow)	--	X	--	--	--	--
*Medicago sativa** (alfalfa)	X	--	X	X	X	X
*Chondrilla juncea** (rush skeletonweed)	X	--		X		X
*Cardaria draba** (whitetop)	X	--	--	--	X	--
Chrysothamnus nauseosus (gray rabbitbrush)	--	0.6	X	X	X	X
Oenothera pallida (evening primrose)	X	--	--	--	--	--
Microsteris gracilis (annual phlox)	--	--	0.1	0.1	--	0.4
*Agastache occidentalis** (western horsemint)	--	--	--	X	--	--
Sphaeralcea munroana (globemallow)	--	--	--	--	X	--
*Centaurea diffusa** (diffuse knapweed)	--	--	--	--	--	X
Bare soil	19.5	29.5	27.7	40.8	42	20.1
Litter	63.6	58.4	57.6	35.5	36.7	63.6
Total (does not include bare soil or litter)	**82.4**	**85.3**	**90.5**	**68.7**	**53.1**	**75.7**

* Introduced Species.
X = Present but not counted in plot frames.
– = Not occurring on plot.

Table 2. Percent Frequency of Occurrence on Horn Rapids Landfill for 1999.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
*Agropyron spp** (wheatgrasses)	80	96	88	92	88	88
*Salsola kali** (Russian thistle)	4	4	4	4	4	4
*Bromus tectorum** (cheatgrass)	92	96	92	80	80	100
Amsinckia lycopsoides (tarweed fiddleneck)	8	X	X	X	--	4
*Sisymbrium altissimum** (tumblemustard)	--	X	4	4	X	--
Ambrosia acanthicarpa (bur ragweed)	8	4	--	--	4	8
*Convolvulus arvensis** (field bindweed)	X	X	X	X	X	X
*Holosteum umbellatum** (jagged chickweed)	100	100	100	100	100	100
*Lactuca serriola** (prickly lettuce)	--	--	--	--	--	--
Draba verna (spring whitlow)	80	80	96	100	100	80
Descurainia pinnata (tansymustard)	4	--	--	--	X	--
Epilobium paniculatum (tall willowherb)	4	--	8	--	--	--
Poa sandbergii (Sandberg's bluegrass)	X	--	4	--	X	X
Plantago patagonica (Indian wheat)	--	--	--	--	--	4
*Erodium cicutarium** (storksbill)	4	--	8	X	4	--
*Tragopogon dubius** (yellow salsify)	X	4	X	--	--	X
Agoseris grandiflora (mountain dandelion)	--	--	X	--	--	--
Eriogonum niveum (snow buckwheat)	X	X	X	--	--	X
Astragalus caricinus (buckwheat milkvetch)	--	--	X	--	--	--
Machaeranthera canescens (hoary aster)	X	X	--	X	--	X
Achillea millefolium (yarrow)	--	X	--	--	--	--
*Medicago sativa** (alfalfa)	X	--	X	X	X	X
*Chondrilla juncea** (rush skeletonweed)	X	--	--	X	--	X
*Cardaria draba** (whitetop)	X	--	--	--	X	--
Chrysothamnus nauseosus (gray rabbitbrush)	--	4	X	X	X	X
Oenothera pallida (evening primrose)	X	--	--	--	--	--
Microsteris gracilis (annual phlox)	--	--	4	4	--	16
*Agastache occidentalis** (western horsemint)	--	--	--	X	--	--
Sphaeralcea munroana (globemallow)	--	--	--	--	X	--
*Centaurea diffusa** (diffuse knapweed)	--	--	--	--	--	X
Bare soil	96	92	88	100	100	96
Litter	100	100	100	100	100	100

* Introduced Species.
X = Present but not counted in plot frames.
-- = Not occurring on plot.

3.0 HORSESHOE LANDFILL

The Horseshoe and the Nike Base landfills are located on the Fitzner-Eberhardt ALE Reserve and are included in the 1100-IU-1 Operable Unit (Figure 3). They were sampled and remediated as part of the remediation work outlined in the ROD for the 1100 Area National Priorities List site (EPA 1993). The completion of the remediation work was documented in the *Close-Out Report Fitzner-Eberhardt Arid Lands Ecology Reserve Remedial Action, Hanford, Washington* (DOE-RL 1996a).

On the Horseshoe Landfill, transects running across the width of the revegetated area were counted. On the three small Nike Landfill sites, all bunchgrasses and sagebrush were counted and the habitat type and canopy cover were classified. The revegetated area of the Horseshoe Landfill measures approximately 35 by 70 m. The revegetated area on the Nike Base Landfill consists of three small sites measuring approximately 4 by 23 m (plot 1), 6 by 9 m (plot 2), and 4 by 9 m (plot 3). The disturbed soils on the surface of these sites were revegetated in the fall of 1995. Work began on November 29, 1995 and was completed on December 7, 1995.

The Horseshoe Landfill was revegetated with transplanted bunchgrasses. The landfill also had a large number of sagebrush seedlings growing on it that were inadvertently planted during the backfilling (i.e., the seeds were already in the soil used to cover the surface). The exceptionally wet winter of 1994/1995 allowed the seeds to grow and become established. The three small Nike Landfill sites varied in vegetative cover from nearly bare to having some small sagebrush, cheatgrass, and Sandberg's bluegrass. These sites were planted with bunchgrasses and an additional 12 to 15 sagebrush seedlings each.

The vegetation growing on the Horseshoe Landfill and a reference site adjacent to the waste site was measured for canopy cover and frequency of occurrence on May 18, 1999, using classic Daubenmire methods (1970). Within the Horseshoe Landfill and the reference site, 25 plot-frames measuring 50 x 100 cm were analyzed.

Survival of the planted bunchgrasses on the Horseshoe Landfill was measured by examining the bunchgrasses for green plant material in the crown area. If there were any green leaves present, the plant was recorded as alive. On the Horseshoe Landfill, transects running across the width of the revegetated area were counted. On the three small Nike Landfill sites, all observed sagebrush were counted, and the habitat type and canopy cover were qualitatively described.

3.1 MONITORING RESULTS

Twenty-nine species of plants were recorded in the plot frames on the Horseshoe Landfill in 1999, 13 of which were native. Six additional native species were observed on the landfill that did not occur in the plot frames. The reference site had 18 species recorded in the plot frames and 3 additional species. Thirteen of the 21 species observed on the reference site were native (Tables 3 and 4). Cheatgrass still has the highest canopy cover on the landfill with 49.6%; notably higher than the 25.5% seen in 1998 (Appendix A, page A-3). Sagebrush cover increased from 14.4% in 1998 to 19.1% in 1999. Bunchgrasses on the waste site are also increasing in dominance through recruitment of seedlings. Bluebunch wheatgrass increased from 3.4% in

1998 to 8.5% in 1999, and Sandberg's bluegrass has remained constant at 9.8% in 1998 and 1999. Sweetclover (*Melilotus officinalis*) showed a sharp decline, from 10.1% in 1998 to only 0.9% in 1999. This is because sweetclover is a biennial species and 1999 was not a year in which these plants increased in biomass and flowered. The canopy cover of the other species has changed only slightly.

The reference site also saw an increase in cheatgrass cover this year of about the same proportion as the waste site. Sagebrush cover appears to have decreased from 30.3% in 1998 to 19% in 1999 at the reference site. Since the plants on the reference site are old-growth shrubs, it is not likely the canopy cover has actually declined. The difference is more likely due to a difference in data collection technique. In 1999, there may have been an inadvertent avoidance of some of the very large shrubs because of the difficulty in maneuvering through them. Also, the shrubs are clustered in this area and not evenly distributed. This would also add to the year-to-year variability because the transects and plot-frame locations are not in the same place every year. Sandberg's bluegrass is the dominant bunchgrass on the reference site with 56.7% cover and 96% frequency. Canopy cover of this species increased by 20.5% in 1999 compared to 1998.

Cryptobiotic crust is an important component of the native shrub-steppe community. It is made up of a mixture of lichens, mosses, and algae that bind the soil surface, thus helping to reduce erosion and facilitate percolation of water. A well-developed cryptobiotic crust is indicative of a mature native community, particularly in areas with fine soils. Ground coverage of biotic crust was measured at these sites. The amount of ground covered with biotic crust on the reference site was 88.7% in 1999, increased from 49.1% in 1998. Cryptobiotic crust on the Horseshoe Landfill increased from 2% in 1998 to 59.3% in 1999. The crust is very thin on the landfill, but the frequency of occurrence was 96%. This is a good indication that the soils are continuing to recover from the disturbance.

The survival of the transplanted native bunchgrasses remains acceptable on the Horseshoe Landfill this year. A total of 197 plants were examined and 139 were alive for a survival of 70.6% (Table 5). Survival of the bunchgrasses has remained fairly consistent since 1997, when it was recorded at 68%, and in 1998 at 70%. With the recruitment of seedlings occurring throughout the site, these survival counts appear to be sufficient to sustain the population and contribute to increased growth. This is demonstrated by the increase in frequency of bluebunch wheatgrass from 36% in 1998 to 52% in 1999.

On the three Nike Landfill sites, as in previous years, transplant survival was difficult to determine. Instead, the total number of live sagebrush at each site was counted and compared to values in previous years. Sagebrush survival and recruitment was high in 1999 for all Nike Landfill sites. Plot 1 contained 60 sagebrush, a 33.3% increase from 1998, and a 78.3% increase from 1997. Plot 2 contained 40 sagebrush, which constituted a 37.5% increase from 1998, and a 62.5% increase from 1997. Plot 3 contained 50 sagebrush, which was a 10% increase from 1998, and a 78% increase from 1997.

Because the Nike Landfill plots are very small, they were described in terms of community composition and canopy cover was estimated over the entire plots as single units. Nike Plot 1 was approximately 50% sagebrush/cheatgrass community, and 50% recovering sagebrush/ bunchgrass. The canopy cover for the entire plot was approximately 63% for cheatgrass,

15% for sagebrush, and 38% for bunchgrass. Nike Plot 2 was approximately 75% sagebrush/ cheatgrass and 25% sagebrush/bunchgrass community, with a total canopy cover of 85% cheatgrass, 15% sagebrush, and 3% bunchgrass. Nike Plot 3 was 75% pure cheatgrass and 25% sagebrush/cheatgrass community. The canopy cover for cheatgrass was approximately 85%, sagebrush was 38%, and bunchgrass was 3%.

Survival of transplanted bunchgrasses was impossible to determine, but recruitment is being seen for both bunchgrasses and sagebrush. This, combined with the increases seen in canopy cover for the bunchgrasses and sagebrush, indicate the health and development on these sites is continuing to improve.

Trends in canopy cover were examined over a duration of 4 years for the Horseshoe Landfill. Species examined were Russian thistle, cheatgrass, sagebrush and bunchgrasses. Canopy cover representation by Russian thistle remained under 1% from 1996 to 1999. All other species showed increasing trends between 1996 and 1999. The density of cheatgrass showed decline from 1997 to 1998, then a recovery and increase in canopy cover from 1998 to 1999. Cheatgrass demonstrated an overall increase of 42.4% over the four year monitoring period (Figure 5).

The grasses at Horseshoe Landfill monitored for trends in canopy cover included the following bunchgrasses: bluebunch wheatgrass, Sandberg's bluegrass, bottlebrush squirreltail (*Sitanion hystrix*), bulbous bluegrass (*Poa bulbosa*), six-weeks fescue, and Indian ricegrass (*Oryzopsis hymenoides*). Grasses at Horseshoe Landfill showed an increasing trend in abundance, rising from 1.7% cover in 1996 to 25.4% cover in 1999 (Figure 5). Individual grass species also showed an increase in representation from year to year.

Sagebrush canopy cover increased from 2.8% to 19.1% between 1996 and 1999. The increase is a result of the maturing sagebrush, and the recruitment of new plants.

Table 3. Percent Canopy Cover on the Horseshoe Landfill in 1999.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	49.6	33.7
Artemisia tridentata (big sagebrush)	19.1	19
Agropyron spicatum (bluebunch wheatgrass)	8.5	2.1
Poa sandbergii (Sandberg's bluegrass)	9.8	56.7
Sitanion hystrix (bottlebrush squirreltail)	0.7	2
Poa bulbosa * (bulbous bluegrass)	0.4	--
Festuca octoflora (six-weeks fescue)	5.9	1.9
Oryzopsis hymenoides (Indian ricegrass)	0.1	2.1
Stipa comata (needle-and-thread-grass)	--	1.5
*Sisymbrium altissimum** (tumblemustard)	4.8	1.1
*Melilotus officinalis** (sweetclover)	0.9	--
Epilobium paniculatum (tall willowherb)	1.5	0.6
*Lactuca serriola** (prickly lettuce)	1.4	0.5
Crepis atrabarba (slender hawksbeard)	0.9	3.7
Salsola kali * (Russian thistle)	0.3	0.4
*Descurainia spp** (tansymustard)	0.2	X
Amsinckia lycopsoides (tarweed fiddleneck)	X	--
Chaenactis douglasii (hoary false yarrow)	X	--
Erigeron filifolius (threadleaf fleabane)	0.1	0.1
Linum perenne (wild blueflax)	X	0.6
*Lepidium perfoliatum** (clasping pepperweed)	0.1	--
Lupinus leucophyllus (velvet lupine)	0.5	4
*Tragopogon dubius** (yellow salsify)	1.4	0.6
Chrysothamnus nauseosus (gray rabbitbrush)	X	--
Chrysothamnus viscidiflorus (green rabbitbrush)	X	--
Helianthus cusickii (Cusick's sunflower)	X	X
Lomatium grayi (Gray's desertparsley)	0.1	0.7
Plantago patagonica (Indian wheat)	0.1	X
Phlox longifolia (longleaf phlox)	0.1	--
*Erodium cicutarium** (storksbill)	X	--
Biotic Crust	59.3	88.7
Bare Soil	19.9	7.9
Litter	74.8	83.6
Total (does not include crust, soil or litter)	**106.5**	**131.3**

* Introduced Species.
X = Present but not counted in the plot frames.
-- = Not occurring on site.

Table 4. Percent Frequency on the Horseshoe Landfill in 1999.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	100	100
Artemisia tridentata (big sagebrush)	76	72
Agropyron spicatum (bluebunch wheatgrass)	52	8
Poa sandbergii (Sandberg's bluegrass)	64	96
Sitanion hystrix (bottlebrush squirreltail)	8	20
*Poa bulbosa** (bulbous bluegrass)	16	--
Festuca octoflora (six-weeks fescue)	44	56
Oryzopsis hymenoides (Indian ricegrass)	4	8
Stipa comata (needle-and-thread-grass)	--	4
*Sisymbrium altissimum** (tumblemustard)	56	24
*Melilotus officinalis** (sweetclover)	36	--
Epilobium paniculatum (tall willowherb)	60	24
*Lactuca serriola** (prickly lettuce)	56	20
Crepis atrabarba (slender hawksbeard)	16	68
*Salsola kali** (Russian thistle)	12	16
*Descurainia spp** (tansymustard)	8	X
Amsinckia lycopsoides (tarweed fiddleneck)	X	--
Chaenactis douglasii (hoary false yarrow)	X	--
Erigeron filifolius (threadleaf fleabane)	4	4
Linum perenne (wild blueflax)	X	24
*Lepidium perfoliatum** (clasping pepperweed)	4	--
Lupinus leucophyllus (velvet lupine)	20	80
*Tragopogon dubius** (yellow salsify)	56	4
Chrysothamnus nauseosus (gray rabbitbrush)	X	--
Chrysothamnus viscidiflorus (green rabbitbrush)	X	--
Helianthus cusickii (Cusick's sunflower)	X	X
Lomatium grayi (Gray's desertparsley)	4	8
Plantago patagonica (Indian wheat)	4	X
Phlox longifolia (longleaf phlox)	4	--
*Erodium cicutarium** (storksbill)	X	--
Biotic Crust	96	100
Bare Soil	96	100
Litter	96	100

* Introduced Species.
X = Present but not counted in the plot frames.
-- = Not occurring on the site.

Table 5. Percent Survival of Transplanted Bunchgrasses and Sagebrush Plants in 1999.

Site Name	Sagebrush			Bunchgrass		
PSN 12/14	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Plot 1	91.3	59		54	66	
Plot 2	75	58		96.8	82	62.9
Plot 3	76.5	73		62.5	74	
Plot 4	93.8	69		66.7	61	46.2
Plot 5	58.1	43		72	76	80.9
Plot 6	57.8	59		74.4	88	69.4
Plot 7	57.3	57		81.3	88	64.2
Bridge Overlook				94		
NS Cheatgrass Area						
Small Plots (Aug)	5.5					
Small Plots (Oct)	92.7					
Road Transect	85.7	81.8	76.7			
Horseshoe Landfill				68	70	70.6
Nike Landfill						
Plot 1				83		
Plot 2				92		
Plot 3				86		
300-FF-1		70	54			
200-ZP-1		54	29			
216-A-25		84	65			
ERDF Mitigation Sagebrush Planting						
Area 1			93			
Area 2			97.8			
Area 3			91.6			
Area 4			70.5			
Area 5			57.8			
116-C-1						
Nonirrigated backfill			100			
Irrigated backfill			91.7			
Nonirrigated Top Soil			83.3			
Irrigated Top Soil			78.9			

Figure 3. Horseshoe and Nike Landfills.

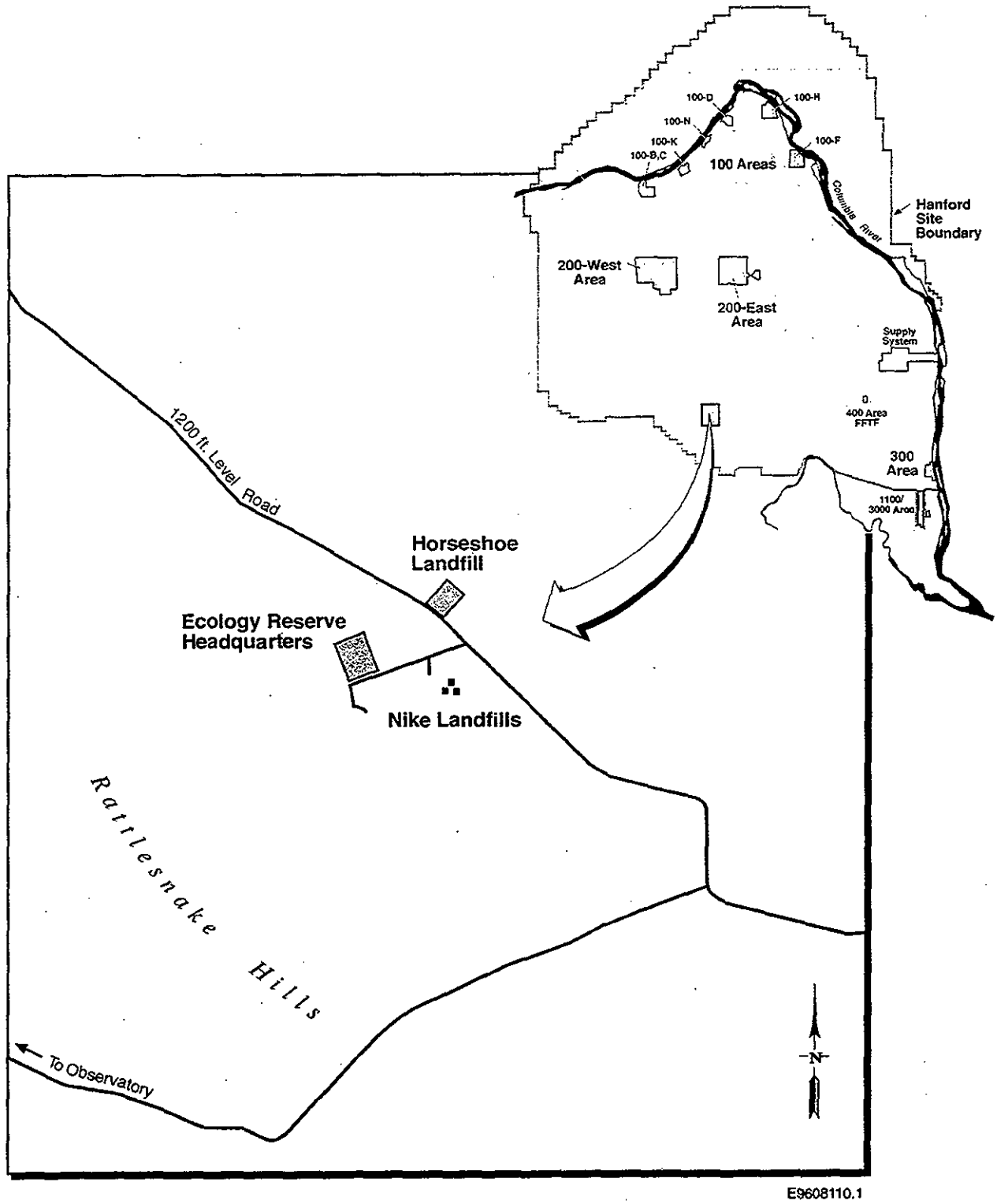


Figure 4. Comparison of Canopy Cover Trends on Horn Rapids Landfill 1996-1999.

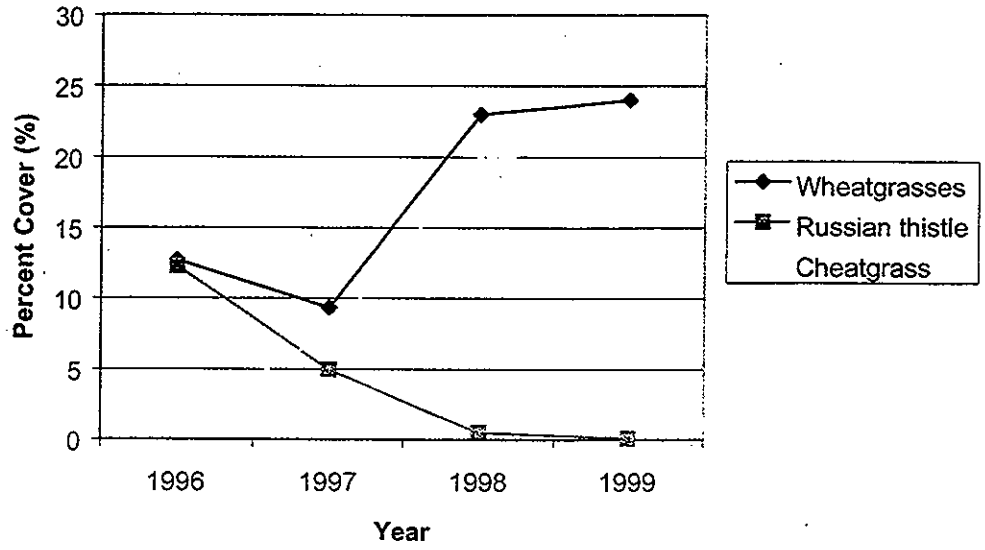
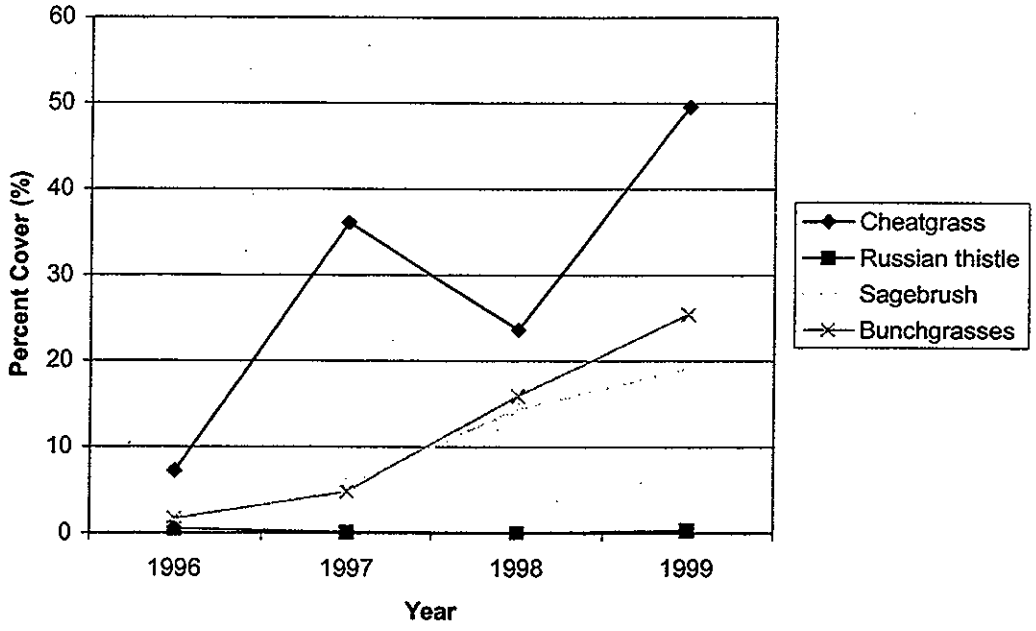


Figure 5. Comparison of Canopy Cover Trends on Horseshoe Landfill 1996-1999.



4.0 NORTH SLOPE SITES

There were 39 distinct waste sites identified within the 100-IU-3 Operable Unit of the 100 Area National Priority List site. The 100-IU-3 Operable Unit is located on the Hanford Site North Slope area. The cleanup of these waste sites was documented in the *Close-Out Report North Slope (Wahluke Slope) Expedited Repose Action, Hanford Washington* (DOE/RL 1994a) to satisfy milestone No. M-16-82 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989 and Lerch 1998a). The sites were remediated and cleanup activities took place in 1994 with the exception of waste site 600-104, which was remediated in 1997. A detailed description of the remediation activities is provided in *A Compendium of Field Reports for the North Slope (Wahluke Slope) Expedited Response Action* (DOE-RL 1994b) and *100-IU-3 Waste Site 600-104 Remediation Summary, January 1998* (Lerch 1998a). The Hanford North Slope was delisted in July 1998 by the U.S. Environmental Protection Agency (EPA) (Federal Register July 8, 1998, Volume 63, Number 130).

Most of the remediation efforts involved the removal of physical hazards associated with military and pre-World War II agricultural activities. Remediated sites included abandoned water wells, debris removal, excavation of landfills, and backfilling of open cisterns. In 1997, a remediation effort was conducted to remove tanks and bioremediate 2,4-D contaminated soils from a Bureau of Reclamation disposal site.

The restoration plan for the North Slope sites was based on the quality of the site surrounding vegetation. The vegetation on and surrounding many of the sites prior to cleanup consisted primarily of cheatgrass, Russian thistle, tumblemustard (*Sisymbrium altissimum*), and other introduced species with some localized recolonization of big sagebrush and Sandberg's bluegrass. The soils at the revegetaionareas aregenerally coarse,well-drained and easily eroded by wind when exposed.

Three North Slope sites (Bridge Overlook, PSN 72/82, and PSN 12/14) were selected for revegetation in 1995 because of surrounding high-quality habitat, project timing, and available resources (Hughes 1995). The revegetation efforts primarily used salvaged plant materials and sagebrush tubelings grown from seed collected on the Hanford Site. An additional area on the North Slope was selected for restoring the sagebrush component to a cheatgrass/Sandberg's bluegrass community after a previous burn (Figure 1). The purpose of planting sagebrush at this site was to compensate for not revegetating a number of very small waste sites within the Hanford North Slope area. Those areas were determined by the Hanford Site Natural Resources Trustee Council to be poor quality habitat. Furthermore, these sites were determined to be either too small or had the potential to be farmed in the future.

Waste site 600-104 (2,4-D waste site) was revegetated on September 29, 1997 after bioremediation of 2,4-D contaminated soils. The dominant species on the waste site were cheatgrass and tumblemustard before the site was exhumed and contaminated soils were bioremediated. After backfilling, the site was seeded with big sagebrush, snow buckwheat, Sandberg's bluegrass, Indian ricegrass, and balsamroot.

4.1 REVEGETATION PLAN BACKGROUND

Native bunchgrass species were salvaged from the Environmental Restoration Disposal Facility (ERDF) and were used for the initial planting on Bridge Overlook, PSN 72/82, and PSN 12/14. An estimated 9,000 (maximum) plants were salvaged from ERDF in February 1995. Of all the salvaged plants, an estimated 90% were needle-and-thread grass (*Stipa comata*), and the remaining 10% were Indian ricegrass, Sandberg's bluegrass, pine bluegrass (*Poa scabrella*), and prairie junegrass (*Koeleria cristata*).

As part of the site preparation, soil samples were taken from each of the three revegetation sites and sent to a local laboratory for percent organic matter, nitrogen, and potassium analysis. The results of the analysis indicated that the soils were deficient in phosphorus. A fertilizer with an analysis of 11-52-0 (11% N, 52% P_2O_5, and 0% K_2O) was recommended to correct the soil fertility deficiency (Hughes 1995). All plants at PSN 72/82 and Bridge Overlook along with an estimated 4,000 plants at three of the PSN 12/14 plots received fertilizer. Volunteer revegetation crews were directed to add 15 ml of fertilizer for plants in 3.8-L pots and 30 ml of fertilizer for plants in larger pots. Additionally, 30 native grass plants at both the Bridge Overlook (with fertilizer) and PSN 12/14 (without fertilizer) were planted in areas of undisturbed soil adjacent to the landfill areas (Hughes 1995). These reference areas were not permanently identified and could not be found in the 1997 or 1998 monitoring effort. Hughes also noted that maintenance irrigation was applied to selected areas of PSN 72/82 and 12/14 throughout the growing season. The Bridge Overlook transplants were not to receive supplemental irrigation due to its remote location and another 886 plants at PSN 12/14 did not receive supplemental irrigation. The different irrigation regimes were done to test the effect of watering on transplant establishment. Unfortunately, the selected areas and plants that were irrigated were not identified in the field by markings or on a map; therefore, monitoring of these treatments was not feasible.

4.2 BRIDGE OVERLOOK

The Bridge Overlook site is located approximately 1 mile northwest of the Vernita Bridge (Figures 1 and 6). The vegetation on the Bridge Overlook site was measured on May 26, 1999. In 1999, a total of 15 plant species were identified on the waste site, 12 of which were native (Tables 6 and 7). Five new species were detected in the 1999 survey within the waste site plot-frames, evening primrose (*Oenothera pallida*), Big sagebrush, tumble mustard, hoary aster and winged cryptantha (*Cryptantha pterocarya*). Cheatgrass was the most abundant plant in canopy cover on the waste site; however, cheatgrass cover has decreased by 6.6% since 1998. Cheatgrass cover on the reference site also declined from the 1998 survey by 29.6% (Table 6 and Appendix A). The cryptobiotic crust, which was absent in 1997, started to develop in 1998 (1.5% cover) and continued to develop to 5.9% cover in 1999. Cover by native forbs, Great Basin gilia (*Gilia leptomeria*) and tansymustard declined from 11.3% and 7.0% to 1.1% and 3.8%, respectively. However, dune scurfpea (*Psoralea lanceolata*) cover increased from 13.6% to 16.4%. Dune scurfpea colonization is stabilizing most of the site. Canopy cover of snow buckwheat has increased since 1998 from 0.6% to 2.3% in 1999. Frequency also increased from 4% to 16% in 1999.

The reference site, located west of the waste site, had 23 plant species within the plot-frames, 21 of which were native plants. The reference site had a cryptobiotic crust component

(24.8% cover), and a dominant shrub canopy of sagebrush (10.9% cover), snow buckwheat (8.4% cover), spiny hopsage (*Grayia spinosa*) (5.5% cover), and antelope bitterbrush (5.4% cover). The reference site had a diverse forb and bunchgrass understory as well.

The survival of transplanted bunchgrasses was very difficult to determine due to the lack of documentation on the number of plants planted and original planting patterns. Furthermore, as plants die and organic material decomposes or blows away, it becomes impossible to distinguish where the transplants resided. The results of survival counts then become artificially high since only the survivors can be counted. Therefore, survival was not measured this year. However, observable bunchgrass recruitment throughout the site indicated continued recovery of the understory community.

4.3 PSN 72/82

The PSN 72/82 site is located near the Bridge Overlook site (Figures 1 and 6). The areas that were revegetated included the PSN 72/82 Well Mound and a small staging area on the access road adjacent to the Well Mound. Sagebrush tubelings and bunchgrass salvaged from ERDF were planted on the Well Mound in March 1995, with fertilizer added to each hole. The 1999 vegetation survey of the Well Mound site identified 17 plant species within the plot-frames and 4 on site but not recorded in a plot-frame, 15 of which were native plants (Tables 8 and 9). Shrub cover and frequency of big sagebrush and gray rabbitbrush on the site has changed slightly from 1998; this change is not due to mortality, but rather the random placement of the plot frames. Big sagebrush decreased from 7.3% to 2.8% cover and gray rabbitbrush increased from 3.0% to 6.5% cover. The four bunchgrass species initially transplanted onto the site were prairie junegrass, Indian ricegrass, Sandberg's bluegrass, and needle-and-thread grass. Percent canopy cover has decreased from 1998 values for needle-and-thread grass (from 5.1% to 1.3% cover) and Sandberg's bluegrass (from 1.3% to 0.2% cover); however, Indian ricegrass, which was not recorded last year, had a canopy cover of 1.2%. Cryptobiotic crust cover has significantly increased since last year from 0.6% to 19.8% cover. Bare soil notably decreased from 90.3% to 31.3% cover from 1998 to 1999. Bunchgrass and sagebrush survival was not counted this year because it was difficult to distinguish the transplants from recruitment that had occurred within the last 4 years. The bunchgrasses and the sagebrush are producing seed and recruitment is now occurring on the site.

On the reference site, a total of 12 plant species were identified, 9 of which were native species. Big sagebrush (18.3% cover) was the dominant shrub overstory species with cheatgrass (29.3% cover), Sandberg's bluegrass (1.3% cover), and six-weeks fescue (1.5% cover) being the main grasses present. The cryptobiotic crust and bare soil cover were 40.7 % and 9.0%, respectively. Litter cover also increased from 35.7% in 1998 to 83.2% in 1999.

The small staging area (road) adjacent to the Well Mound site, was planted in the fall of 1996 with a seed mix of sagebrush, snow buckwheat, spring turpentine parsley, Carey's balsamroot, and Sandberg's bluegrass. A total of 20 plant species were identified, 15 of which were native species (Tables 8 and 9). All planted species, except spring turpentine parsley, were identified on the site. The percent canopy cover increased from 6.6% to 12.8% in 1999 for six weeks fescue and 0.3% to 2.5% for Carey's balsamroot. In addition to the planted species, the site is being colonized by many native species including annual phlox, spring whitlow, tansy mustard,

hoary aster and matted cryptantha. The initial development of cryptobiotic crust yielded 3.1% cover with a reduction in bare ground cover from 81.3% in 1998 to 58.6% in 1999.

4.4 PSN 12/14

The PSN 12/14 site is located in the northeast corner of the Hanford Site, approximately 6.4 km east of the White Bluffs Landing (Figures 1 and 7). Both sagebrush tubelings and salvaged bunchgrasses from ERDF were planted on all seven PSN 12/14 plots from March 27 through April 1, 1995. The access road into the PSN 12/14 waste sites was revegetated in the fall of 1996 with a seed mix consisting of sagebrush, bitterbrush, snow buckwheat, spring turpentine parsley, Carey's balsamroot, and Sandberg's bluegrass.

In 1999, monitoring consisted of estimating percent canopy cover and percent frequency of occurrence on plots 1, 2, 4, 5, the access road, and a reference site. Survival of the transplanted bunchgrasses was also evaluated on plots 1, 2, 4, 5, 6, and 7 (table5).

The access road remains dominated by cheatgrass but the percent cover is considerably lower than last year with a reduction from 45.2% to 11.1%. Twenty plant species were identified within the plot-frames, 15 of which were native plants (Tables 10 and 11). Only bitterbrush and spring turpentine parsley have not been detected on the access road since seeding. New native species colonizing the access road in 1999 included tansymustard, yarrow, buckwheat milkvetch, and winged dock. Litter remains limited on the access road compared to the other PSN 12/14 sites, and a cryptobiotic crust has not yet begun to develop.

On the waste sites, all plots were dominated by cheatgrass. Plots 1 and 4 have increased cheatgrass coverage from last year by 8.8% and 7.5% respectively, while plot 2 reduced cheatgrass cover from 42.5% to 26.1%. Russian thistle coverage did not have a notable change since 1998, remaining consistently low on all plots except for a slight elevation on plot 2, which has increased from 0.5% to 10% cover. There was a notable decrease in tumblemustard on plots 1 and 4, from 16.5% to 4.3% and 21.3% to 6.3% cover, respectively, with all other plots remaining fairly consistent. Plot 5 had the highest coverage and frequency of native bunchgrasses with significant recruitment. This plot also had five additional native species not counted in the plot-frames. All four waste sites have shown reductions in bare ground. Plots 1 and 4 showed an increase in the cryptobiotic crust layer by 33.8 % and 37.9% cover, respectively.

On the reference site, a total of 24 plants were identified, 18 of which were native species. The bare soil component had decreased from 40.3% cover to 17.2% in 1999, and the incidence of cryptobiotic crust increased from 36.3% in 1998 to 66.3% cover in 1999. Cheatgrass had the highest frequency and coverage of any plant, followed by jagged chickweed ($f_{cheatgrass}$=100%; $f_{chickweed}$=88%). The shrub canopy included sagebrush, bitterbrush, green rabbitbrush (*Chrysothamnus viscidiflorus*), and snow buckwheat. Sandberg's bluegrass, bulbous bluegrass, and Indian ricegrass comprised the bunchgrass understory, while dominant forbs included spring turpentine parsley, longleaf (*Phlox longifolia*) and annual phlox, tansymustard, and bastard toadflax (*Comandra umbellatum*).

The survival of transplanted sagebrush and bunchgrass was difficult to determine because the original planting patterns were often unidentifiable. As plants die and decompose, it becomes impossible to determine transplants from recruited plants. Therefore, rather than collecting data that will conclude artificially high survivorship, stand health was qualitatively recorded. Sagebrush survival was reduced overall with very limited recruitment throughout the plots, except for plots 1 and 4. Plot 1 had approximately 50% survival with noticeable sagebrush reproduction but reduced bunchgrass survival. Plot 4 had some reproduction but generally limited survival of sagebrush transplants, as expected for sandy dune areas where bitterbrush might be a more favorable overstory species. Plot 6 had several mature sagebrush and bitterbrush along the perimeter of the plot acting as seed sources for regeneration but no noticeable recruitment yet. Bunchgrass transplant survival ranged from 46.2% for plot 4 to 80.9% survival for plot 5 equaling an average bunchgrass survival for plots 2, 4, 5, 6, and 7 of 64.7% (Table 5). Bunchgrasses were surviving well on most of the plots and demonstrating active recruitment. On plots 5 and 7, native colonies of thickspike wheatgrass have advanced approximately 1 to 2 m from last year's survey.

4.5 NORTH SLOPE CHEATGRASS AREA

Sagebrush seedlings were planted in August and October, 1996 in a burned area on the Saddle Mountain Wildlife Refuge (Figures 1 and 8). These burned areas have had the sagebrush component removed due to repeated wildfires. The objective of this planting was to provide a seed source in the area to promote sagebrush regeneration.

Approximately 3,000 sagebrush were planted in groups of three along an access road in August 1996. These sagebrush were salvaged as seedlings from gravel pits at the junction of the access road and Highway Route 24. Different planting methods were used during the August transplanting. All of the sagebrush were planted directly in the ground and watered. In one treatment, sagebrush were surrounded by black plastic to help control weed competition. Sagebrush in another treatment were planted with Dri-Water™ a commercial product composed of a vegetable gel that slowly releases water into soil over an extended period of time. The survival of these sagebrush was extremely poor; only 5.5% after the first year. Therefore, these areas were not monitored in 1999.

Approximately 2,700 sagebrush were planted in October 1996. These sagebrush were salvaged from an area south of the Hanford Site 300 Area. The plantings were done in groups of three along the access road (road transect) and in small transect plots that were established perpendicular to the access road. The road transect was divided into three sections (Figure 8) and surveyed for survivorship in June 1999. Sagebrush survival for sections 1, 2, and 3 were 79.9%, 74.2% and 76.0% with an average survival of 76.7%. The height of the sagebrush in sections 1 and 2 ranged 25 to 60 cm while the height of the sagebrush in section 3, which is in rockier soils closer to the Columbia River, were smaller ranging 15 to 45 cm. Sagebrush survival along this transect has been declining slowly from 86% in 1997 and 82% in 1998 (Table 5); however, the survivorship measured this year is still considered excellent.

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The dramatic improvement in survivorship of sagebrush planted in October versus August shows that late summer planting may not be a successful approach. High average daily temperatures (92.6° F) (Hoitink and Burk 1997), and injury to root systems while salvaging sagebrush from gravelly soils were primary factors in the low survivorship of the August 1997 plantings.

4.6 WASTE SITE 600-104

Waste site 600-104 (2,4-D site) is located approximately 9.7 km south of PSN 12/14 and approximately 1 km east of the Columbia River (Figure 1). The 1-hectare site was used by the Bureau of Reclamation to dispose of 11 empty tanks as well as soil contaminated with 2,4-D. In 1997, the site was dominated primarily by cheatgrass and tumblemustard. In August 1997, the tanks were exhumed and bio-remediation of 2,4-D contaminated soils took place. On September 28, 1998, the site was seeded by hand with 1 kg/ha of uncleaned big sagebrush seed, 0.75 kg/ha snow buckwheat, 5 kg/ha Sandberg's bluegrass, 1 kg/ha Indian ricegrass, and 20 kg/ha balsamroot. After hand broadcasting the seed using a fertilizer spreader, the planted area was watered with 5 cm of water (approximately 100,000 L of water over the entire site).

A total of 32 species had colonized the site by May 1999, of which 25 were native species. Thirteen species were present on the waste site in 1998, all of which were present in 1999. Seventeen native species were observed within the plot-frames, and an additional 8 natives were observed on the site as incidentals. Russian thistle and cheatgrass were the dominant species with 45.6% and 20.8% canopy cover, respectively (Table 12). Cheatgrass decreased from 34.7% in 1998 and Russian thistle increased from 6.2%. The increase in Russian thistle cover was probably a result of the lack of competition from other species. Incidences of sagebrush, snow buckwheat, and Indian ricegrass were observed for the first time in 1999. With the presence of so many other species now on the site (31 other than Russian thistle), it is expected that in future years the canopy cover of Russian thistle will decrease as the other species become more established.

Percent frequency of cheatgrass remained at 96% between 1998 and 1999, but frequency of Russian thistle increased from 56% to 100% this year. Yarrow was the third most frequent occurrence at the waste site, increasing from 4% to 32% frequency from 1998 to 1999. The increase in the number of colonizing species, specifically native species, indicates the area is beginning to recover from the 1997 remedial action disturbance.

Table 6. Percent Canopy Cover on Bridge Overlook Sites in 1999.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	17.8	20.5
*Salsola kali** (Russian thistle)	4.2	0.2
Ambrosia acanthicarpa (bur ragweed)	1.1	--
Psoralea lanceolata (dune scurfpea)	16.4	0.7
Stipa comata (needle-and-thread-grass)	1.9	0.7
Gilia leptomeria (great basin gilia)	1.1	0.1
Mentzelia albicaulis (whitestem stickleaf)	--	0.4
Oenothera pallida (evening primrose)	1.2	0.6
Descurainia spp (tansymustard)	3.8	0.4
Cryptantha circumscissa (matted cryptantha)	0.8	0.7
Eriogonum niveum (snow buckwheat)	2.3	8.4
Artemisia tridentata (big sagebrush)	3.4	10.9
Purshia tridentata (antelope bitterbrush)	--	5.4
Chrysothamnus viscidiflorus (green rabbitbrush)	--	0.6
Grayia spinosa (spiny hopsage)	X	5.5
Oryzopsis hymenoides (Indian ricegrass)	X	0.6
Festuca octoflora (six-weeks fescue)	--	0.3
Cymopterus terebinthinus (turpentine parsley)	X	1.6
Layia grandulosa (white-daisy tidytips)	0.6	0.3
Comandra umbellatum (bastard toadflax)	--	1.5
Microsteris gracilis (annual phlox)	0.1	--
Balsamorhiza careyana (Carey's balsamroot)	--	2.7
Machaeranthera canescens (hoary aster)	2.5	0.1
Cryptantha pterocarya (winged cryptantha)	1	0.2
*Melilotus alba** (sweetclover)	X	--
Poa sandbergii (Sandberg's bluegrass)	--	0.1
Koeleria cristata (prairie junegrass)	X	X
*Sisymbrium altissimum** (tumblemustard)	0.1	--
Biotic crust	5.9	24.8
Bare soil	52.5	34.5
Litter	50.8	56.5
Total (does not include crust, soil or litter)	**58.2**	**60.1**

* Introduced species.
X = Present but not counted on plot frames.
-- = Not occurring on site.

Table 7. Percent Frequency of Occurrence on Bridge Overlook Sites in 1999.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	68	96
*Salsola kali** (Russian thistle)	72	8
Ambrosia acanthicarpa (bur ragweed)	24	--
Psoralea lanceolata (dune scurfpea)	60	8
Stipa comata (needle-and-thread-grass)	16	8
Gilia leptomeria (great basin gilia)	24	4
Mentzelia albicaulis (whitestem stickleaf)	--	16
Oenothera pallida (evening primrose)	8	4
Descurainia spp (tansymustard)	52	16
Cryptantha circumscissa (matted cryptantha)	12	32
Eriogonum niveum (snow buckwheat)	16	48
Artemisia tridentata (big sagebrush)	4	20
Purshia tridentata (antelope bitterbrush)	--	8
Chrysothamnus viscidiflorus (green rabbitbrush)	--	4
Grayia spinosa (spiny hopsage)	--	12
Oryzopsis hymenoides (Indian ricegrass)	--	4
Festuca octoflora (six-weeks fescue)	--	12
Cymopterus terebinthinus (turpentine parsley)	X	24
Layia grandulosa (white-daisy tidytips)	4	12
Comandra umbellatum (bastard toadflax)	--	40
Microsteris gracilis (annual phlox)	4	--
Balsamorhiza careyana (Carey's balsamroot)	--	12
Machaeranthera canescens (hoary aster)	4	4
Cryptantha pterocarya (winged cryptantha)	20	8
*Melilotus alba** (sweetclover)	X	--
Poa sandbergii (Sandberg's bluegrass)	--	4
Koeleria cristata (prairie junegrass)	X	X
*Sisymbrium altissimum** (tumblemustard)	4	--
Biotic crust	44	56
Bare soil	100	100
Litter	100	100

* Introduced species.
X = Present but not counted on plot frames.
-- = Not occurring on site.

Table 8. Percent Canopy Cover on PSN 72/82 Well Mound Sites in 1999.

Species	Waste Site	Road	Reference Site
*Bromus tectorum** (cheatgrass)	13	34.7	29.3
*Salsola kali** (Russian thistle)	1.3	0.1	0.3
Ambrosia acanthicarpa (bur ragweed)	1.2	1.6	--
Oenothera pallida (pale evening primrose)	X	--	--
Artemisia tridentata (big sagebrush)	2.8	1.8	18.3
Chrysothamnus nauseosus (gray rabbitbrush)	6.5	X	X
Koeleria cristata (prairie junegrass)	X	--	--
Poa sandbergii (Sandberg's bluegrass)	0.2	0.3	1.3
Sitanion hystrix (bottlebrush squirreltail)	0.2	--	--
Stipa comata (needle-and-thread grass)	1.3	--	--
Oryzopsis hymenoides (Indian ricegrass)	1.2	--	--
Festuca octoflora (six-weeks fescue)	2.8	12.8	1.5
Microsteris gracilis (annual phlox)	0.8	1.7	1.5
*Holosteum umbellatum** (jagged chickweed)	0.8	4.1	1.2
Draba verna (spring whitlow)	6.7	10.2	1.7
*Lactuca serriola** (prickly lettuce)	0.2	X	--
Amsinckia lycopsoides (tarweed fiddleneck)	X	0.6	X
*Sisymbrium altissimum** (tumblemustard)	1	1.4	X
Descurainia spp (tansymustard)	--	0.2	0.3
*Erodium cicutarium** (storksbill)	1.3	0.1	--
Balsamorhiza careyana (Carey's balsamroot)	--	2.5	5.2
Machaeranthera canescens (hoary aster)	1.7	3.1	X
Cryptantha circumscissa (matted cryptantha)	--	2.6	X
Eriogonum niveum (snow buckwheat)	--	3.9	--
Plantago patagonica (Indian Wheat)	--	0.4	--
Gilia leptomeria (great basin gilia)	--	0.3	--
Cryptantha pterocarya (winged cryptantha)	--	0.1	--
Astragalus spp.	X	--	--
*Agropyron cristatum** (crested wheatgrass)	--	--	X
Phlox longifolia (longleaf phlox)	--	--	1.0
Epilobium paniculatum (tall willowherb)	--	--	0.7
Biotic Crust	19.8	3.1	40.7
Bare soil	31.3	58.6	9.0
Litter	55.5	40.1	83.2
Total (does not include crust, soil or litter)	**43**	**86.2**	**62.3**

* Introduced Species.
X = Present but not counted in plot frames.
-- = Not occurring on site.

Table 9. Percent Frequency of Occurrence on PSN 72/82 Well Mound Sites in 1999.

Species	Waste Site	Road	Reference Site
*Bromus tectorum** (cheatgrass)	100	92	93.3
*Salsola kali** (Russian thistle)	53.3	4	13.3
Ambrosia acanthicarpa (bur ragweed)	46.7	44	--
Oenothera pallida (pale evening primrose)	X	--	--
Artemisia tridentata (big sagebrush)	20	12	40
Chrysothamnus nauseosus (gray rabbitbrush)	6.7	X	X
Koeleria cristata (prairie junegrass)	X	--	--
Poa sandbergii (Sandberg's bluegrass)	6.7	12	20
Sitanion hystrix (bottlebrush squirreltail)	6.7	--	--
Stipa comata (needle-and-thread grass)	20	--	--
Oryzopsis hymenoides (Indian ricegrass)	13.3	--	--
Festuca octoflora (six-weeks fescue)	46.7	84	26.7
Microsteris gracilis (annual phlox)	33.3	68	26.7
*Holosteum umbellatum** (jagged chickweed)	33.3	48	46.7
Draba verna (spring whitlow)	80	64	66.7
*Lactuca serriola** (prickly lettuce)	6.7	X	--
Amsinckia lycopsoides (tarweed fiddleneck)	X	4	X
*Sisymbrium altissimum** (tumblemustard)	40	36	X
Descurainia spp (tansymustard)	--	8	13.3
*Erodium cicutarium** (storksbill)	53.3	4	--
Balsamorhiza careyana (Carey's balsamroot)	--	4	20
Machaeranthera canescens (hoary aster)	33.3	84	X
Cryptantha circumscissa (matted cryptantha)	--	64	X
Eriogonum niveum (snow buckwheat)	--	20	--
Plantago patagonica (Indian Wheat)	--	16	--
Gilia leptomeria (great basin gilia)	--	12	--
Cryptantha pterocarya (winged cryptantha)	--	8	--
Astragalus spp.	X	--	--
*Agropyron cristatum** (crested wheatgrass)	--	--	X
Phlox longifolia (longleaf phlox)	--	--	6.7
Epilobium paniculatum (tall willowherb)	--	--	26.7
Biotic Crust	67	44	73
Bare Soil	100	100	100
Litter	100	100	100

* Introduced Species.
X = Present but not counted in plot frames.
-- = Not occurring on site.

Table 10. Percent Canopy Cover on PSN 12/14 Sites in 1999.

Species	Reference	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	63.3	19.8	34.3	28	37.3	11.1
Ambrosia acanthicarpa (bur ragweed)	0.6	1.7	1.6	1.4	0.7	4.1
*Sisymbrium altissimum** (tumblemustard)	1.7	0.5	6.3	2.6	4.3	0.2
*Salsola kali** (Russian thistle)	0.6	2.2	3.4	10	4.8	0.9
Artemisia tridentata (big sagebrush)	13.3	0.1	1.4	1.7	1.5	2.2
Purshia tridentata (antelope bitterbrush)	4.7	--	--	0.1	--	--
Chrysothamnus viscidiflorus (green rabbitbrush)	4	X	--	--	--	3.8
Chrysothamnus nauseosus (gray rabbitbrush)	--	--	--	--	2.7	1.2
Poa sandbergii (Sandberg's bluegrass)	15.4	1.9	6.9	3.6	6.5	0.1
*Poa bulbosa** (bulbous bluegrass)	0.7	--	--	--	--	0.1
Stipa comata (needle-and-thread grass)	--	12.6	3.1	8.1	5.7	--
Oryzopsis hymenoides (Indian ricegrass)	2.5	6.5	X	--	X	--
Agropyron dasytachyum (thickspike wheatgrass)	--	11.7	--	--	--	--
Amsinckia lycopsoides (tarweed fiddleneck)	X	--	0.1	0.2	--	--
Cymopterus terebinthinus (turpentine parsley)	2.2	--	--	X	--	--
Descurainia spp (tansymustard)	1.4	0.7	2.3	--	X	0.1
Epilobium paniculatum (tall willowherb)	0.6	--	0.7	0.1	1.3	0.1
Eriogonum niveum (snow buckwheat)	1.6	3.8	--	--	--	3.1
Festuca octoflora (six-weeks fescue)	--	0.4	0.1	--	--	--
*Holosteum umbellatum** (jagged chickweed)	26.9	1.1	21.3	18.2	30.2	3.6
Draba verna (spring whitlow)	10.1	--	--	2	3.8	1.1
*Lactuca serriola** (prickly lettuce)	0.2	--	2.7	0.4	2.8	--
Machaeranthera canescens (hoary aster)	0.1	X	0.8	0.1	0.7	0.2
Microsteris gracilis (annual phlox)	2.4	--	0.1	11.3	0.5	--
Oenothera pallida (pale evening primrose)	0.2	0.9	--	0.5	--	--
Phlox longifolia (longleaf phlox)	3.6	--	--	0.1	--	--
Comandra umbellatum (bastard toadflax)	2.1	--	--	--	--	--
Achillea millefolium (yarrow)	X	0.6	0.1	0.3	0.2	3.5
*Tragopogon dubius** (yellow salsify)	--	X	0.1	X	0.3	--
Psoralea lanceolata (dune scurfpea)	--	--	--	4.4	--	--
Balsamorhiza careyana (Carey's balsamroot)	X	--	--	--	--	0.2
Lappula redowskii (Western stickweed)	--	--	--	--	0.2	0.3
Poa scabrella (pine bluegrass)	--	X	--	--	--	--
Koeleria cristata (prairie junegrass)	--	X	--	--	--	--
Brodiaea douglasii (Douglas' clusterlily)	0.7	--	--	--	--	--
Rumex venosus (winged dock)	--	--	--	--	--	0.2
Astragalus caricinus (buckwheat milkvetch)	--	--	0.1	--	--	0.2
Sitanion hystrix (bottlebrush squirreltail)	--	X	X	--	--	--
Fritilllaria pudica (yellow bell)	0.1	--	--	--	--	--
Crepis atrabarba (slender hawksbeard)	X	--	--	--	--	--
Cryptantha circumscissa (matted cryptantha)	X	--	--	--	--	--
Biotic crust	66.3	--	46.4	4.4	41.3	--
Bare soil	17.2	66.8	30.1	30.9	27.0	78
Litter	83.5	27.4	65.6	57.5	55.3	1.2
Total cover (does not include crust, soil, or litter)	**159**	**64.5**	**85.4**	**93.1**	**103.5**	**36.3**

* Introduced species.
X = Present but not counted in plot frames.
-- = Not occurring on the plot.

Table 11. Percent Frequency of Occurrence on PSN 12/14 Sites in 1999.

Species	Reference	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	100	100	100	96	100	84
Ambrosia acanthicarpa (bur ragweed)	24	68	44	56	27	68
*Sisymbrium altissimum** (tumblemustard)	12	20	44	48	73	8
*Salsola kali** (Russian thistle)	24	88	76	92	67	36
Artemisia tridentata (big sagebrush)	36	4	16	12	60	12
Purshia tridentata (antelope bitterbrush)	16	--	--	4	--	--
Chrysothamnus viscidiflorus (green rabbitbrush)	8	X	--	--	--	32
Chrysothamnus nauseosus (gray rabbitbrush)	--	--	--	--	13	28
Poa sandbergii (Sandberg's bluegrass)	56	16	64	28	60	4
*Poa bulbosa** (bulbous bluegrass)	8	--	--	--	--	4
Stipa comata (needle-and-thread grass)	--	64	44	40	33	--
Oryzopsis hymenoides (Indian ricegrass)	4	12	X	--	X	--
Agropyron dasytachyum (thickspike wheatgrass)	--	28	--	--	--	--
Amsinckia lycopsoides (tarweed fiddleneck)	X	--	4	8	--	--
Cymopterus terebinthinus (turpentine parsley)	12	--	--	X	--	--
Descurainia spp (tansymustard)	16	8	16	--	X	4
Epilobium paniculatum (tall willowherb)	24	--	28	4	53	4
Eriogonum niveum (snow buckwheat)	8	20	--	--	--	28
Festuca octoflora (six-weeks fescue)	--	16	4	--	--	--
*Holosteum umbellatum** (jagged chickweed)	88	44	92	92	93	68
Draba verna (spring whitlow)	68	--	--	40	27	44
*Lactuca serriola** (prickly lettuce)	8	--	68	16	80	--
Machaeranthera canescens (hoary aster)	4	X	32	4	27	8
Microsteris gracilis (annual phlox)	76	--	4	72	20	--
Oenothera pallida (pale evening primrose)	8	36	--	20	--	--
Phlox longifolia (longleaf phlox)	12	--	--	4	--	--
Comandra umbellatum (bastard toadflax)	24	--	--	--	--	--
Achillea millefolium (yarrow)	X	4	4	12	7	8
*Tragopogon dubius** (yellow salsify)	--	X	4	X	13	--
Psoralea lanceolata (dune scurfpea)	--	--	--	24	--	--
Balsamorhiza careyana (Carey's balsamroot)	X	--	--	--	--	8
Lappula redowskii (Western stickweed)	--	--	--	--	7	12
Poa scabrella (pine bluegrass)	--	X	--	--	--	--
Koeleria cristata (prairie junegrass)	--	X	--	--	--	--
Brodiaea douglasii (Douglas' clusterlily)	8	--	--	--	--	--
Rumex venosus (winged dock)	--	--	--	--	--	8
Astragalus caricinus (buckwheat milkvetch)	--	--	4	--	--	8
Sitanion hystrix (bottlebrush squirreltail)	--	X	X	--	--	--
Fritilllaria pudica (yellow bell)	4	--	--	--	--	--
Crepis atrabarba (slender hawksbeard)	X	--	--	--	--	--
Cryptantha circumscissa (matted cryptantha)	X	--	--	--	--	--
Biotic crust	92	--	100	100	100	0
Bare soil	92	96	100	100	100	100
Litter	100	100	100	96	100	28

* Introduced species.
X = Present but not counted in plot frames.
-- = Not occurring on the plot.

Table 12. Percent Canopy Cover and Frequency of Occurrence on 600-104 (2,4-D).

Species	% Cover	% Frequency
*Bromus tectorum** (cheatgrass)	20.8	96
*Salsola kali** (Russian thistle)	45.6	100
*Sisymbrium altissimum** (tumblemustard)	0.7	28
Ambrosia acanthicarpa (bur ragweed)	0.6	24
Descurainia spp (tansymustard)	0.2	8
Poa sandbergii (Sandberg's bluegrass)	0.7	8
Festuca octoflora (six-weeks fescue)	0.5	20
Rumex venosus (winged dock)	0.2	8
Lappula redowskii (Western stickweed)	0.2	8
Amsinckia lycopsoides (tarweed fiddleneck)	0.3	12
*Holosteum umbellatum** (jagged chickweed)	0.7	28
Draba verna (spring whitlow)	0.2	8
Achillea millefolium (yarrow)	1.8	32
Oenothera pallida (pale evening primrose)	0.1	4
Epilobium paniculatum (tall willowherb)	0.4	16
*Lactuca serriola** (prickly lettuce)	0.6	24
Microsteris gracilis (annual phlox)	0.2	8
Artemisia tridentata (big sagebrush)	0.1	4
Machaeranthera canescens (hoary aster)	0.1	4
Phlox longifolia (longleaf phlox)	0.7	8
Eriogonum niveum (snow buckwheat)	0.1	4
Mentzelia albicaulis (whitestem stickleaf)	0.1	4
Lupinus pusillus (low lupine)	X	
Oryzopsis hymenoides (Indian Rice grass)	X	
*Poa bulbosa** (bulbous bluegrass)	X	
Balsamorhiza careyana (Carey's balsamroot)	X	
*Tragopogon dubius** (yellow salsify)	X	
Astragalus spp.	X	
Chaenactis douglasii (hoary falseyarrow)	X	
Chrysothamnus viscidiflorus (green rabbitbrush)	X	
Chrysothamnus nauseosus (gray rabbitbrush)	X	
Thelypodium laciniatum (cutleaf ladyfoot mustard)	X	
Bare soil	54.8	100
Litter	25.3	100
Total Cover (does not include bare soil or litter)	**74.9**	

* Introduced species.
X = Present but not counted in plot frames.

Figure 6. PSN 72/82 and Bridge Overlook Revegetation Sites.

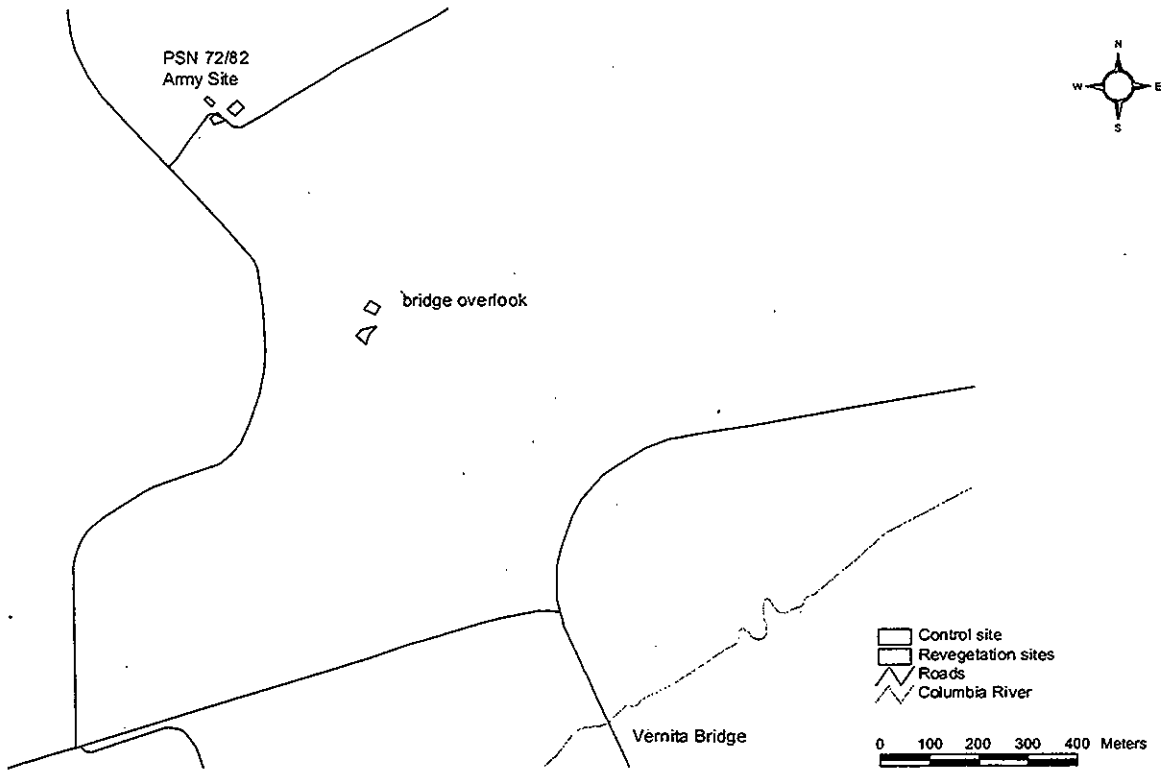


Figure 7. PSN 12/14 Revegetation Sites.

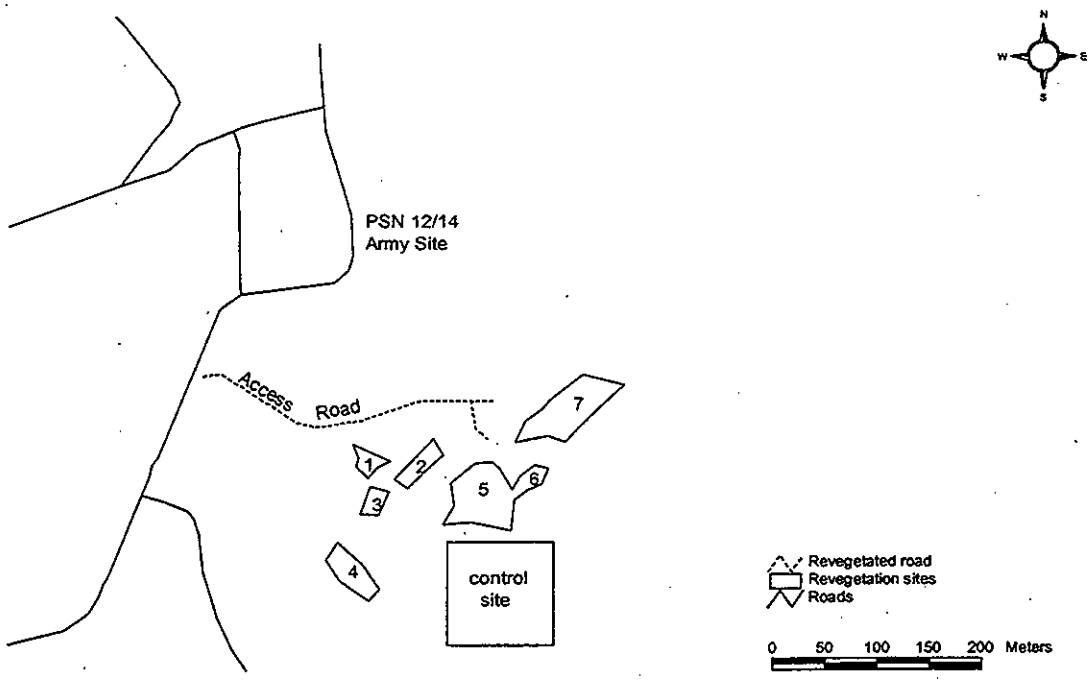
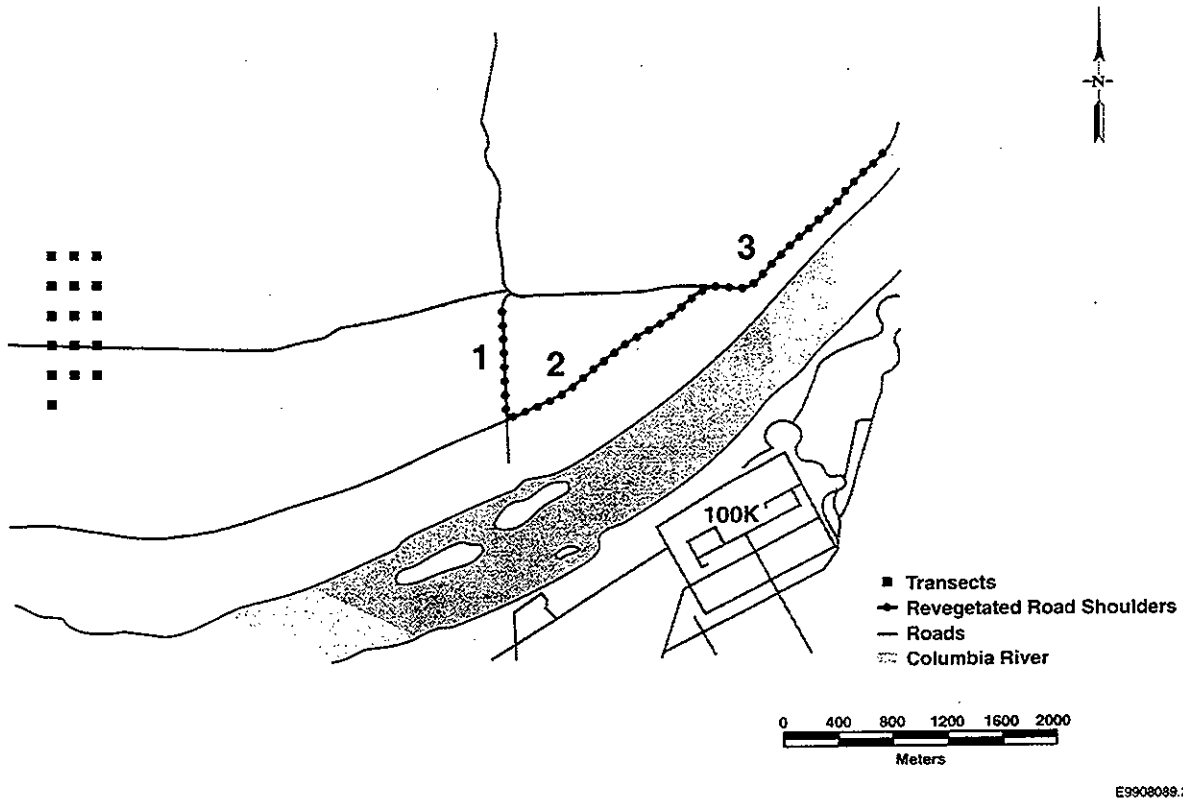


Figure 8. Sagebrush Transplant Sites on the North Slope Cheatgrass Area.



5.0 SAGEBRUSH PLANTINGS IN THE 200 AND 300 AREAS

5.1 216-A-25 EMERGENCY EXTENSION SITE

On February 11, 1998, a total of 1,000 sagebrush tubelings were planted in groups of three to mitigate for interim stabilization of the 216-A-25 emergency extension site. The sagebrush were planted using a small straight crowbar to create a hole for planting the tubelings. The soil was then gently pushed in to fill any void spaces around the roots. The soil moisture during planting conditions was ideal.

On July 12, 1999 a count of sagebrush to determine survival found 60 live and 32 dead sagebrush for a survival rate of 65%. A number of other sagebrush were planted but due to the height of the cheatgrass, only those groups of three with pin-flags remaining could be counted. Survival in 1998 was shown to be 84% for 100 tubelings counted in the planted area. The total canopy coverage of the site remains nearly 100% cheatgrass.

5.2 300-FF-1

On October 16 – 17, 1997, a total of 24 antelope bitterbrush were salvaged from the perimeter of the 618-4 Burial Ground and moved 200 m east. The salvaging effort was conducted to mitigate for the loss of mature shrubs on the 618-4 burial ground during grubbing and remediation of the site (Weiss, 1996). The salvaged plants averaged 0.25 to 0.5 m in height and were replanted in groups of three over a 500 m^2 area. The plants were removed with a "1/4 yard backhoe" and moved directly to the planting hole with a minimum of handling.

The soil around the burial ground where the shrubs were salvaged had a thin veneer of fine soil covering coarse, sandy gravel. Using extreme care, the shrubs were lifted from the ground, taking as much soil as possible to reduce damage to the root systems. However, because the soil was so coarse, most of it fell apart during the extraction, breaking most of the fine roots. Before planting, the hole in which the salvaged plant was to be placed was filled with water and allowed to drain.

On August 31, 1998, the transplanted bitterbrush was examined for survival and all 24 plants had died. The loss of the fine roots during excavation of the plants is likely the major cause of the failure. A contributing factor may also have been the dry sandy soil at the transplant sites, even though water was provided during transplanting.

On December 2, 1997, a total of 293 2-year old container grown sagebrush plants were planted over an area of 3,100 m^2 just north of the bitterbrush planting area (Figure 9). This planting was additional mitigation for the loss of shrubs on the 618-4 Burial Ground. Five rows of plants were placed in clusters of 3, spaced 0.5 to 1.0 m apart, with each cluster approximately 4.6 m apart.

On June 22, 1999, the planted area was examined to determine survivorship. A total of 164 live plants were counted, yielding a survivorship of 54%, notably lower than 70% found in 1998. The plant height ranged from about 15 to 30 cm. Some plants were very healthy and beginning

to form flower buds while others showed signs of stress, including yellowing leaves. However, only 11 out of the 98 planting locations had all three sagebrush plants dead.

5.3 200-ZP-1 PIPELINE

The 200-ZP-1 Injection Well Pipeline is located on the western edge of the 200 West Area (Figure 1). On September 28, 1997, a total of 600 sagebrush tubelings were planted in the 200-ZP-1 pipeline corridor to replace habitat that was lost during construction of the 200-ZP-1 injection well system. After planting, the tubelings were watered because of dry soil conditions. Sandberg's bluegrass and snow buckwheat were also seeded at 5 kg/ha and 1.5 kg/ha.

On July 12, 1999 sagebrush were counted on the east-west section of the pipeline and there were 64 sagebrush out of the 200 originally planted still alive with 83 sagebrush recruited into the road area. On the north-south section leading to the injection wells, there were 111 out of the 400 original plants still alive with 137 sagebrush recruited into the area. The combined survivorship of the two areas is 29%. There are areas with very good seeding of Sandberg's bluegrass, rabbitbrush, and balsamroot, as well as a number of other native and nonnative species that have colonized the site. Although the planted sagebrush survival is lower than expected, the revegetated area is relatively narrow (20 m wide) and bordered on both sides by mature stands of sagebrush. This healthy seed source along the perimeter on the site should continue to increase the number of shrubs on the site. Therefore, additional planting is not being considered at this time.

6.0 300 NORTH PROCESS TRENCH

6.1 316-5 PROCESS TRENCH

The 300 Area Process Trench became active in 1975 as a replacement for the north and south process pond system in the 300 Area (Figure 9). The trenches received 300 Area process effluent from the uranium fuel fabrication facilities. In addition, liquid waste from the 300 Area laboratories that was determined to be below discharge limits was also discharged into the trenches. The 300 Area Process Trench consisted of two parallel, unlined trenches approximately 468 m long, 3 m wide and 3.7 m deep, spaced 15 m apart. The trenches were covered with screens to minimize access by birds to the sediments in the bottom of the trenches.

Trench remediation activities were initiated in July 1997 and completed in February 1998. Approximately 34,000 metric tons of the contaminated soil and debris were excavated and loaded into containers for shipment to ERDF. A majority of the bulk tonnage was uranium contaminated soils; however, a concrete headwork structure at the inlet to the two trenches and bird screens comprised of wood framing and wire mesh were also demolished and sent to ERDF as well (Lerch 1998b).

Upon completion of remediation, the majority of the 316-5 process trench was re-graded and contoured with the surrounding soils immediately adjacent to the trench with a bulldozer in mid- to late 1998. A small portion of one of the trenches was not re-graded due to its close proximity to the North Process Pond (NPP) work area, but will be completed with the NPP work. In long range planning, the 300 Area has been designated industrial (EPA 1996b). Therefore, the area of the re-graded trench was broadcast seeded with approximately 50 kg per hectare of crested wheatgrass. Straw mulch was blown over the seeded area at a rate of 4.5 metric tons per hectare, then crimped into the soil using a disk.

The initial vegetation analysis was measured on July 1, 1999. A total of 21 plant species were observed on the site, 13 of which were native species (Table 13). Domestic wheat (*Triticum spp.*) was the most abundant plant in the canopy cover due to residual seed in the straw mulch applied on the site. However, as seen on other sites, such as the HRL, this species will disappear from the plant community as competition from other species increase through the years. Crested wheatgrass canopy cover was low at 2%; however, a high germination rate occurred, resulting in a frequency of 80% in the plot-frames. As expected, the cryptobiotic crust has not begun to develop and a majority of the litter recorded was the straw mulch.

Figure 9. 300 North Process Trench and 300-FF-1 Sagebrush Transplant Area.

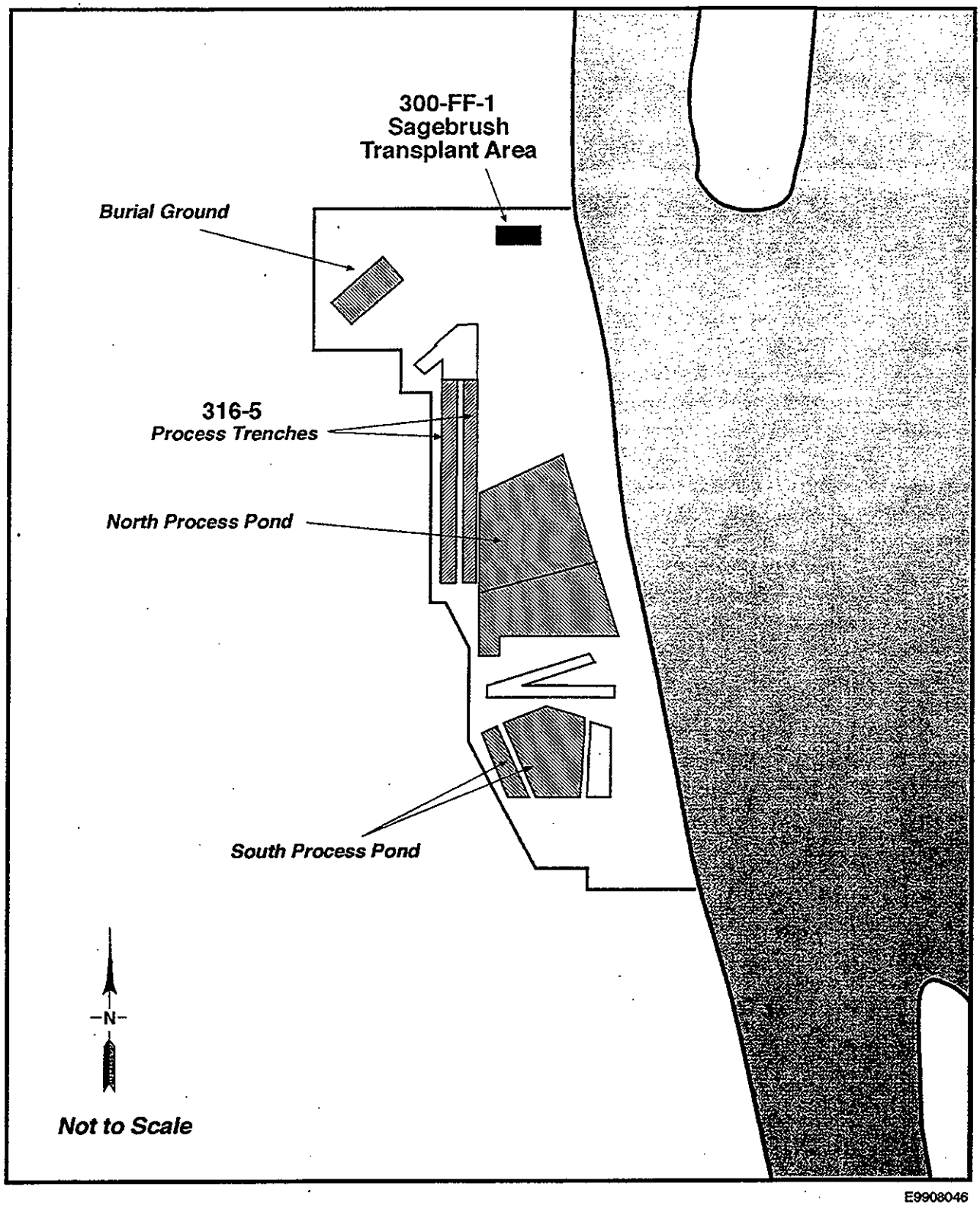


Table 13. Percent Canopy Cover and Frequency of Occurrence on 300 North Process Trench in 1999.

Species	% Cover	% Frequency
*Triticum spp.** (wheat)	10	100
*Bromus tectorum** (cheatgrass)	6.25	100
*Salsola kali** (Russian thistle)	8.5	100
*Agropyron cristatum** (crested wheatgrass)	2	80
Ambrosia acanthicarpa (bur ragweed)	3	70
Microsteris gracilis (annual phlox)	0.5	20
*Holosteum umbellatum** (jagged chickweed)	2.25	90
Draba verna (spring whitlow)	1.5	60
*Lactuca serriola** (prickly lettuce)	1.5	60
Amsinckia lycopsoides (tarweed fiddleneck)	3.25	80
*Sisymbrium altissimum** (tumble mustard)	4.5	80
*Erodium cicutarium** (storksbill)	2.5	50
Machaeranthera canescens (hoary aster)	0.75	30
Plantago patagonica (Indian wheat)	1.75	70
*Melilotus alba** (sweetclover)	0.25	10
Psoralea lanceolata (dune scurfpea)	0.25	10
Epilobium paniculatum (tall willowherb)	0.25	10
Phacelia hastata (whiteleaf scorpionweed)	0.25	10
Poa sandbergii (Sandberg's bluegrass)	X	
Eriogonum niveum (snow buckwheat)	X	
Oenothera pallida (evening primrose)	X	
Biotic Crust	0	
Bare Soil	64	
Litter	22.75	
Total (does not include crust, soil or litter)	**49.25**	

* Introduced species.
X = Present but not counted on plot frames.

7.0 ENVIRONMENTAL RESTORATION DISPOSAL FACILITY MITIGATION SITES

In November 1998, 73,800 sagebrush seedlings were planted as compensatory mitigation for 20.25 hectares (50 acres) of mature sagebrush habitat lost to the expansion of the ERDF. Sagebrush habitat is considered a priority habitat by Washington State because it supports a diverse assemblage of species. The loss of this habitat affects a number of arid lands fauna, including Sage sparrow (*Amphispiza belli*) and the Loggerhead shrike (*Lanius ludovicianus*), both of which are species of concern on the Hanford Site requiring mitigation if impacted. The *Hanford Site Biological Resources Management Plan* (DOE-RL 1996b) requires that if more than 1 hectare (2.47 acres) of this habitat is destroyed, then compensatory mitigation must take place at a rate of 3:1. The planting of the 73,800 sagebrush took place in shrubless areas on the ALE. The plants were distributed at a rate of approximately 988 plants/hectare (400 plants per acre) over a total of 77 hectare (191 acres). This resulted in a compensation ratio of approximately 4:1.

The goal of this mitigation project is to replace the habitat lost to the two bird species listed above. It is anticipated that when the shrubs mature, the habitat will also support sage thrashers (*Oreoscoptes montanus*) and potentially sage grouse (*Centrocercus urophasianus*). Sage thrashers currently reside in sage communities on ALE and sage grouse may occur but in very small numbers.

In preparation for this project, an Interagency Agreement (DOE-RL 1997) was drawn between the U.S. Department of Energy and the United States Fish and Wildlife Service, which called for the cultivation and planting of 75,000 sagebrush seedlings. Native seeds were collected from the Hanford Site in 1997 and sent to three native plant nurseries: Lucky Peak of Boise, Idaho; Plants of the Wild of Teko, Washington; and the Umatilla Native Plant Nursery of the Confederated Tribes of the Umatilla Indian Reservation in Umatilla, Oregon. In November 1998, 45,000 bare-root sagebrush were provided by Lucky Peak; 25,000 tubeling sagebrush were provided by Plants of the Wild; and an additional 3,800 bare-root seedlings were provided by the Umatilla Native Plant Nursery.

Five areas (Figure 1) on ALE were selected for revegetation and habitat enhancement through the planting of tubeling and bare-root sagebrush. The criteria for selecting the plots to be planted were to locate sites with north facing slopes of draws, to include areas dominated with cheatgrass, areas of mixed cheatgrass/bunchgrasses, and pure bunchgrass areas. The intent was to take advantage of more favorable soil moisture conditions that exist in such areas. Sagebrush seedlings were planted by four workers from C&N Forestry of Coeur d'Alene, Idaho, at a rate of 9,600 plants per day. Tubelings and bare-root seedlings were planted in rows, with individuals spaced approximately 3.4 m apart.

Area 1 consisted of 2-hectare (5-acre) plots located to the east of the "1200-Foot Road" along north-facing draws. One was planted with bare-root plants from Lucky Peak, and the second plot planted with tubelings from Plants of the Wild (Figure 10).

Area 2 consisted of 20, 0.8-hectare (2-acre) plots planted with bare-root tubelings from Lucky Peak. Plots were established to the east and west of the ALE Powerline road that leads toward gate 113 on State highway 240 (Figure 10).

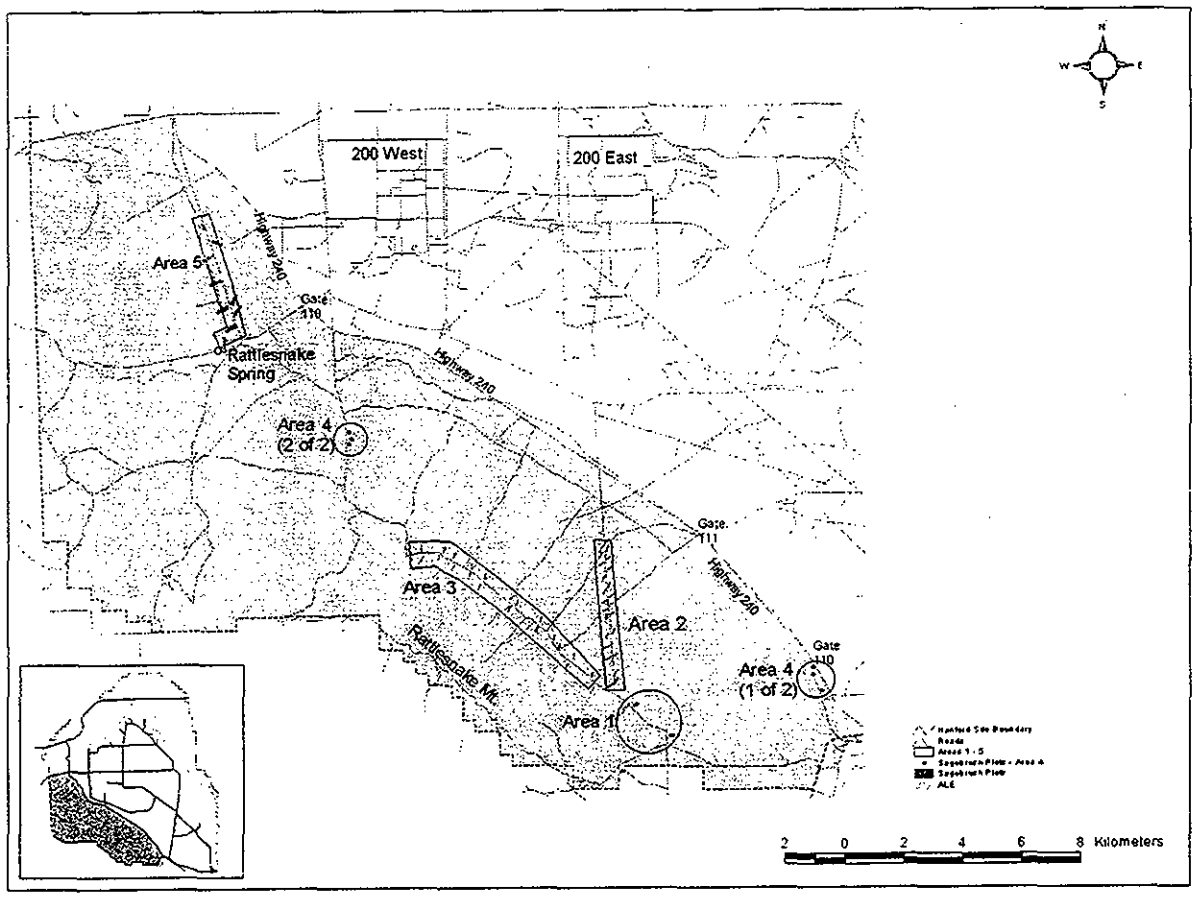
Area 3 consisted of 19, 0.8-hectare (2-acre) plots planted with tubelings from Plants of the Wild. Plots were located in north-facing draws on alternating north and south sides of the "1200-Foot Road" (Figure 10).

Area 4 was split into subareas A and B. Subarea A, located near gate 110, consisted of three 1.6-hectare (4-acre) plots, planted with bare-root sagebrush from Lucky Peak. Subarea B, located near Benson Ranch, consisted of three 0.8-hectare (2-acre) plots planted with tubelings. Both areas contain three small, 0.2-hectare (0.5-acre) student plots that are a mixture of bare-root and tubelings (Figure 10).

Area 5 was located along a road running north from Rattlesnake Springs, in a region burned by a lightning-caused fire in the summer of 1997. Area 5 consisted of eight 4-hectare (10-acre) plots and one 2-hectare (5-acre) plot planted with alternating bare-root and tubeling sagebrush Plot 5-8 was planted with bare-root seedlings from the Umatilla nursery (Figure 10).

Sagebrush survival was assessed in February and March of 1999 to get an initial estimate of survival before the stresses of summer drought. Representative plots of each area were selected and 100 plants (dead and alive) were marked with small stakes so they could be located in future counts. Survival of sagebrush was assessed at one plot in Area 1, five plots in Area 2, five plots in Area 3, and five plots in Area 5. A plant was considered alive if any portion of it was green. Bare-root seedlings from Lucky Peak had the highest percent survival, averaging 95% for all plots sampled. Overall tubeling survival averaged 80.8%. Area 2 had the highest overall survival, with 97.8 %, followed by Area 1 at 93%, and Area 3 at 91.6%. Area 5, a mixture of tubelings and bare-root, had the lowest average survival, at only 57.8%. Of the five plots at Area 5, three plots had survival above 80%, but low survival was encountered in the remaining two plots; 14% survival at a tubeling site and 18% at the Umatilla nursery bare-root site (Table 5). Low survival on these two plots may have been due to ground hardness and the lack of moisture retention in the soil. While installing the marking stakes on these two plots, the soil was observed to be very hard just below the surface (approximately 7 to 12 cm), compared to soft soils on other plots in Area 5 with high-survival rates. The Sandberg's bluegrass on these two plots also appeared to be stressed from lack of water. Factors that could have contributed to the lack of success on these two plots include below normal precipitation, above-normal wind causing soil desiccation; and shallow soil over a layer of compacted silty clay or caliche.

Figure 10. Environmental Restoration Disposal Facility Mitigation Areas.



8.0 116-C-1 REVEGETATION

The 116-C-1 site was remediated as a part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) Remedial Action Project for the 100-B/C Area (EPA 1995). Revegetation at the 116-C-1 site was done as a demonstration project to evaluate practical methods for revegetating remediated sites with native species. Additional goals of the revegetation are to stabilize the site and encourage growth of native vegetation.

Four treatments were employed on the remediated site. The backfill material used for remediation was a coarse assortment of cobble, gravel, and sand from a nearby borrow pit and served as the soil planting medium for two of the four treatments. The backfill material is representative of natural occurring soils that were deposited as the Columbia river changed course over time. The other two treatments used topsoil grubbed from the ERDF excavation in the summer of 1995. On November 5, 1998, a seed mix of native species was planted across four treatments (Weiss 1998): irrigated backfill, irrigated topsoil, nonirrigated topsoil, and nonirrigated backfill (Figure 11). Sandberg's bluegrass (11.2 kg/ha), Indian ricegrass (2.2 kg/ha), and sagebrush (1.1 kg/ha) were planted using a range-drill. Snow buckwheat (.56 kg/ha), Carey's balsamroot (.56 kg/ha), yarrow (.28 kg/ha), needle-and-thread grass 1.1 kg/ha), and additional Indian ricegrass (.28 kg/ha) were planted by hand-broadcasting the seed. Cryptogamic soil/dust (9.1 kg) was also hand-cast over the east half of the site to inoculate the soil surface and stimulate the growth of this important soil component. Following the seeding, wheat straw mulch was applied at the rate of 6.7 metric tons per hectare, then crimped. After the straw was crimped into the soil, 201 tubeling sagebrush were planted in groups of three across the four treatments. Irrigation was applied to one-half of the backfill (cobble) substrate, and one-half of the topsoil substrate from March 15 to June 4 1999 (Table 14).

In June 1999, 24 plant species were found at the 116-C-1 site. Sixteen of the 24 species were natives, including all 7 species of native seeds planted. On June 2, 1999, 25 Daubenmire plot-frames were used to assess canopy cover and frequency of occurrence on each of the four treatments. The species count was highest on the topsoil treatment areas. The nonirrigated site had 21 species and the irrigated site had 15 species. Conversely, canopy cover was highest on the irrigated topsoil treatment with a total cover of 49.4%, followed by the nonirrigated topsoil at 34% (Table 15).

The two cobble treatment areas had the lowest species count and canopy cover. The irrigated backfill had 15 species and a total canopy cover of 8%. The nonirrigated backfill had 14 species and a total canopy cover of 4.3% (Table 16).

The topsoil treatments expressed significantly higher frequency of cheatgrass than the backfill treatments. The frequency for the irrigated and nonirrigated topsoil was 88% and 68% respectively, while the irrigated and nonirrigated backfill was 20% and 12%, respectively. This is typical of how cheatgrass responds to fine-grained soils as opposed to coarse soils. Fine-grained soils hold soil moisture longer and higher in the soil profile, thus favoring the establishment of cheatgrass. Cobbles act as mulch and promote deep percolation of moisture favoring deep-rooted native species. Sandberg's bluegrass had slightly higher frequency and canopy cover in the fine-grained soil treatment. Survival of sagebrush seedlings at the 116-C-1 site was high, with survival of 179 out of 201 plants for an overall survival of 89%. Sagebrush

seedling survival was highest, at 100% on the nonirrigated backfill treatment. High survival was also observed on other treatments, with 91.7 % survival on the irrigated backfill, 83.3% on the nonirrigated topsoil, and 78.9% on the irrigated topsoil (Table 17). A majority of the sagebrush mortality was a result of deer uprooting the tubelings, which were frequently observed intact near the planting sites.

The results from the first year of monitoring at any site are seldom sufficient to predict the final outcome of any revegetation effort. The fact that all species planted were seen on the plots and some, including Sandberg's bluegrass and needle-and-thread grass, were seen in the plot-frames of all treatments including those not irrigated in an unusually dry spring, suggests a successful planting. Comparisons of canopy cover can be misleading in the first few years of a revegetation project due to the lower growth rates of native perennials and the high percent canopy covers of invasive nonnative species, especially Russian thistle.

Success in the future will be assessed on the native plant community's progression through succession and recruitment success. The rate in which a native plant community proceeds through succession depends on several environmental factors including soil type, local precipitation, wind, and competition from nonnative species. Therefore, comparisons and judgements of succession rates and success among and between different locations should be made with caution.

Table 14. Irrigation Applied to 116-C-1 in 1999.

	Water (inches)		Average Monthly Rainfall (1947 to Present)
	Irrigation	Monthly Rainfall 1999	
March 15-31	0.37	0.06	0.47
April	0.83	Trace	0.41
May	0.67	0.34	0.51
June 1-4	0.44	0.31	0.38
Total	**2.3**	**0.71**	**1.77**

Table 15. Percent Canopy Cover on 116-C-1 in 1999. (2 Pages)

Species	Irrigated Backfill	Irrigated Topsoil	Nonirrigated Topsoil	Nonirrigated Backfill
*Bromus tectorum** (cheatgrass)	0.5	19.5	11.3	0.3
*Salsola kali** (Russian thistle)	1.9	14.9	12.8	1.2
Poa sandbergii (Sandberg's bluegrass)	1.1	3.2	2.5	0.5
Stipa comata (needle-and-thread grass)	1.2	0.6	0.3	0.2
*Triticum spp** (wheat)	2.5	4.9	5.1	1.9
Achillea millefolium (yarrow)	X	--	X	--
Agropyron spp	X	X	X	--
Ambrosia acanthicarpa (bur ragweed)	--	0.1	0.1	X
Amsinckia lycopsoides (tarweed fiddleneck)	--	--	0.1	--
Artemisia tridentata (big sagebrush)	X	X	X	--
Balsamorhiza careyana (Carey's balsamroot)	0.1	--	--	--
Chenopodium spp	--	--	0.1	--
Chrysothamnus nauseosus (gray rabbitbrush)	0.5	0.3	0.6	X
Descurainia spp (tansymustard)	X	2.1	0.7	X
Epilobium paniculatum (tall willowherb)	0.2	0.1	--	X
Eriogonum niveum (snow buckwheat)	X	X	X	X
*Erodium cicutarium** (storksbill)	--	--	--	X
*Holosteum umbellatum** (jagged chickweed)	--	--	X	X
*Lactuca serriola** (prickly lettuce)	X	0.1	0.1	0.1
Mentzelia albicaulis (whitestem stickleaf)	--	--	0.1	--
Oenothera pallida (pale evening primrose)	--	--	X	--
Oryzopsis hymenoides (Indian ricegrass)	--	X	X	--
*Sisymbrium altissimum** (tumblemustard)	X	3.6	0.1	--
*Tragopogon dubius** (yellow salsify)	--	--	0.1	0.1
Bare soil	20.5	19.4	19.1	42.3
Litter	71.8	69.9	70.9	52.6
Total (does not include soil or litter)	**8**	**49.4**	**34**	**4.3**

* Introduced species.
X = Present but not counted in plot frames.
-- = Not present on site.

Table 16. Percent Frequency of Occurence on 116-C-1 in 1999.

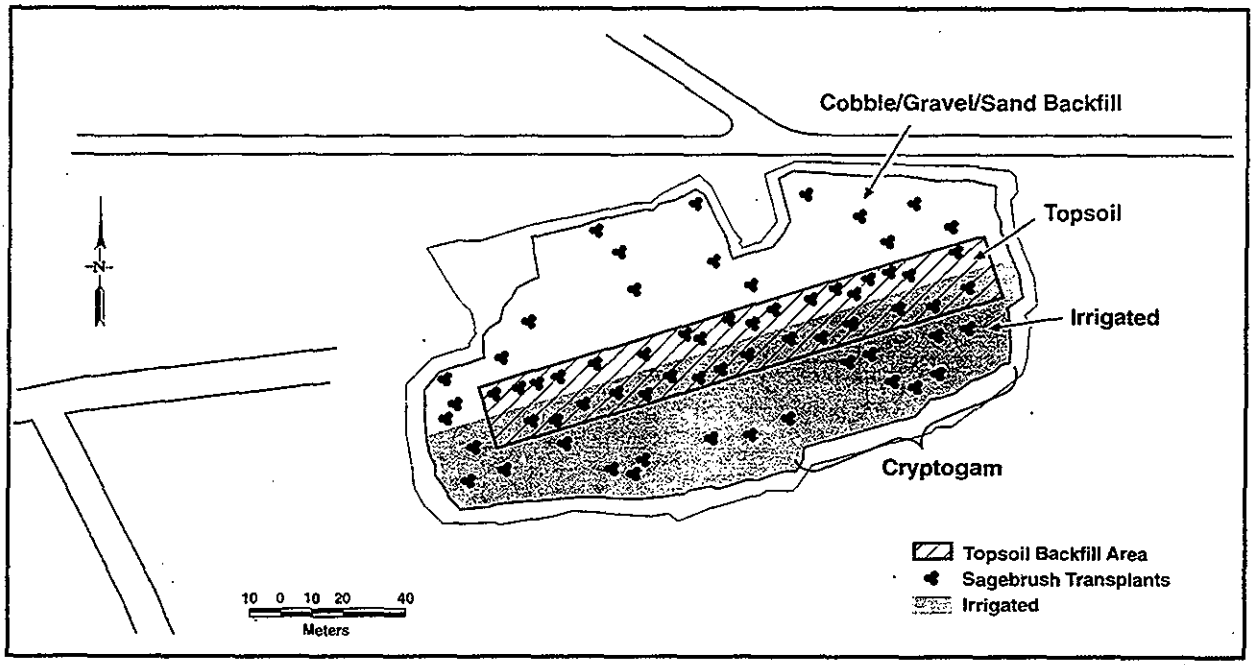
Species	Irrigated Backfill	Irrigated Topsoil	Nonirrigated Topsoil	Nonirrigated Backfill
*Bromus tectorum** (cheatgrass)	20	88	68	12
*Salsola kali** (Russian thistle)	76	76	88	48
Poa sandbergii (Sandberg's bluegrass)	44	48	60	20
Stipa comata (needle-and-thread grass)	48	24	12	8
*Triticum spp** (wheat)	80	56	64	76
Achillea millefolium (yarrow)	X	--	X	--
Agropyron spp	X	X	X	--
Ambrosia acanthicarpa (bur ragweed)	--	4	4	X
Amsinckia lycopsoides (tarweed fiddleneck)	--	--	4	--
Artemisia tridentata (big sagebrush)	X	X	X	--
Balsamorhiza careyana (Carey's balsamroot)	4	--	--	--
Chenopodium spp	--	--	4	--
Chrysothamnus nauseosus (gray rabbitbrush)	20	12	24	X
Descurainia spp (tansymustard)	X	24	8	X
Epilobium paniculatum (tall willowherb)	8	4	--	X
Eriogonum niveum (snow buckwheat)	X	X	X	X
*Erodium cicutarium** (storksbill)	--	--	--	X
*Holosteum umbellatum** (jagged chickweed)	--	--	X	X
*Lactuca serriola** (prickly lettuce)	X	4	4	4
Mentzelia albicaulis (whitestem stickleaf)	--	--	4	--
Oenothera pallida (pale evening primrose)	--	--	X	--
Oryzopsis hymenoides (Indian ricegrass)	--	X	X	--
*Sisymbrium altissimum** (tumblemustard)	--	28	4	--
*Tragopogon dubius** (yellow salsify)	--	--	4	4
Bare soil	20	72	60	96
Litter	100	100	100	100

* Introduced species.
X = Present but not counted in plot frames.
-- = Not present on site.

Table 17. Sagebrush Seedling Survival on 116-C-1.

	Irrigated Backfill	Irrigated Topsoil	Nonirrigated Topsoil	Nonirrigated Backfill
Sagebrush survival (ratio alive:dead)	33:3	45:12	35:7	66:0
Percent survival	91.7%	78.9%	83.3%	100%

Figure 11. 116-C-1 Treatment Areas.



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APPENDIX A

1998 REVEGETATION MONITORING RESULTS

Table A-1. Percent Canopy Cover on Horn Rapids Landfill for 1998.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	15.9	24	23.5	21.6	24.7	26.7
Salsola kali (Russian thistle)	0.2	0.3	0.6	1.1	0.9	0.1
Bromus tectorum (cheatgrass)	23.4	18.6	25.8	9.5	7	34.8
Amsinckia lycopsoides (tarweed)	0.3	0.1	2.2	--	--	0.7
Sisymbrium altissimum (tumblemustard)	--	0.3	0.1	0.3	0.2	--
Ambrosia acanthicarpa (bur ragweed)	0.2	0.5	--	0.2	0.3	0.4
Convolvulus arvensis (field bindweed)	--	--	--	0.1	--	--
Holosteum umbellatum (jagged chickweed)	10.1	25.9	16.4	20.8	10.6	8.3
Lactuca serriola (prickly lettuce)	--	--	0.5	0.1	--	--
Draba verna (spring whitlow)	2.1	9.7	3.8	24	8.8	4.2
Descurainia pinnata (tansymustard)	0.1	0.1	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	0.4	0.2	0.6	0.4	--
Poa sandbergii (Sandberg's bluegrass)	--	--	0.6	--	X	0.1
Plantago patagonica (Indian wheat)	0.1	--	--	--	--	--
Erodium cicutarium (storksbill)	0.3	0.7	0.2	0.2	--	0.1
Tragopogon dubius (yellow salsify)	0.1	--	--	--	--	--
Agoseris grandiflora (mountain dandelion)	--	0.1	--	0.1	--	--
Stipa comata (needle and thread grass)	--	--	--	--	--	X
Chaenactis douglasii (hoary falseyarrow)	--	--	--	--	--	X
Phacelia hastata (whiteleaf scorpionweed)	--	--	--	--	--	X
Eriogonum niveum (snow buckwheat)	--	--	--	--	--	X
Astragalus caricinus (buckwheat milkvetch)	--	--	--	--	--	X
Machaeranthera canescens (hoary aster)	--	--	--	--	X	X
Achillea millefolium (yarrow)	--	--	X	--	--	--
*Medicago sativa** (alfalfa)	--	--	X	--	--	--
*Melilotus officinalis** (yellow sweet clover)	--	--	X	--	--	--
*Convolvulus arvensis** (field bindweed)	--	--	X	--	--	--
Chondrilla juncea * (skeletonweed)	--	--	X	--	--	--
*Cardaria draba** (whitetop)	--	--	--	--	X	--
Bare Soil	59.8	53.4	46	84.3	85.3	58.5
Litter	38.9	36.7	51.4	14.3	9.4	34.8
Crust	--	--	0.1	--	--	--
Total *	**52.8**	**80.7**	**73.9**	**78.6**	**52.9**	**75.4**

* Does not include bare soil, litter, or crust.
X = Present but not counted in plot frames.

Table A-2. Percent Frequency of Occurrence on Horn Rapids Landfill for 1998.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	68	88	84	88	100	80
Salsola kali (Russian thistle)	8	12	24	24	36	4
Bromus tectorum (cheatgrass)	100	76	100	88	88	100
Amsinckia lycopsoides (tarweed)	12	4	12	--	--	8
Sisymbrium altissimum (tumblemustard)	--	12	4	12	8	--
Ambrosia acanthicarpa (bur ragweed)	8	20	--	8	12	16
Convolvulus arvensis (field bindweed)	--	--	--	4	--	--
Holosteum umbellatum (jagged chickweed)	96	96	96	100	100	84
Lactuca serriola (prickly lettuce)	--	--	20	4	--	--
Draba verna (spring whitlow)	68	92	92	100	100	48
Descurainia pinnata (tansymustard)	4	4	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	16	8	24	16	--
Poa sandbergii (Sandberg's bluegrass)	--	--	4	--	--	4
Plantago patagonica (Indian wheat)	4	--	--	--	--	--
Erodium cicutarium (storksbill)	12	8	8	8	--	4
Tragopogon dubius (yellow salsify)	4	--	--	--	--	--
Agoseris grandiflora (mountain dandelion)	--	4	--	4	--	--
Bare Soil	100	100	96	100	100	96
Litter	100	100	100	100	100	100
Crust	--	--	4	--	--	--

Table A-3. Percent Canopy Cover on the Horseshoe Landfill in 1998.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	25.5	15.7
Artemisia tridentata (big sagebrush)	14.4	30.3
Agropyron spicatum (bluebunch wheatgrass)	3.4	8.2
Poa sandbergii (Sandberg's bluegrass)	9.8	36.2
Sitanion hystrix (bottlebrush squirreltail)	1	0.2
*Poa bulbosa** (bulbous bluegrass)	0.2	--
Festuca octoflora (sixweeks fescue)	1.5	1.6
Oryzopsis hymenoides (Indian ricegrass)	X	2.8
*Sisymbrium altissimum** (tumblemustard)	0.3	--
*Melilotis officinalis** (sweet clover)	10.1	--
Epilobium paniculatum (tall willowherb)	0.6	0.6
*Lactuca serriola** (prickly lettuce)	1.1	0.2
Crepis atrabarba (slender hawksbeard)	1.9	3.7
Descurainia sp (tansymustard)	0.7	0.1
Amsinckia lycopsoides (tarweed fiddleneck)	0.1	--
Chaenactis douglassi (hoary falseyarrow)	0.1	--
Erigeron filifolius (threadleaf fleabane)	0.1	0.9
Linum perenne (wild blueflax)	0.3	0.1
*Lepidium perfoliatum** (clasping pepperweed)	1.6	--
Lupinus sulphurous (sulfur lupine)	0.6	8.8
*Tragopogon dubius** (yellow salsify)	0.2	0.3
Machaeranthera canescens (hoary aster)	0.8	0.1
Holosteum umbellatum (jagged chickweed)	2.4	0.4
Draba verna (spring whitlow)	--	3.2
Agoseris grandiflora (mountain dandelion)	0.1	--
Chrysothamnus nauseosus (gray rabbitbrush)	1.3	--
Chrysothamnus viscidiflorus (green rabbitbrush)	0.6	--
Achillea millefolium (yarrow)	X	--
Helianthus cusickii (Cusick's sunflower)	X	--
Lomatium macrocarpum (bigseed desertparsley)	X	--
Festuca idahoensis (Idaho fescue)	X	--
Bare soil	10.8	3.6
Biotic crust	2	49.1
Total (does not include crust or soil)	**78.7**	**113.4**

* Introduced species.

X = Present but not counted in plot frames.

Table A-4. Percent Frequency on the Horseshoe Landfill in 1988.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	100	76
Artemisia tridentata (big sagebrush)	64	76
Agropyron spicatum (bluebunch wheatgrass)	36	24
Poa sandbergii (Sandberg's bluegrass)	64	100
Sitanion hystrix (bottlebrush squirreltail)	20	8
*Poa bulbosa** (bulbous bluegrass)	8	--
Festuca octoflora (sixweeks fescue)	40	44
Oryzopsis hymenoides (Indian ricegrass)	--	16
*Sisymbrium altissimum** (tumblemustard)	12	--
*Melilotis officinalis** (sweet clover)	56	--
Epilobium paniculatum (tall willowherb)	24	24
*Lactuca serriola** (prickly lettuce)	44	8
Crepis atrabarba (slender hawksbeard)	16	68
Descurainia sp (tansymustard)	28	4
Amsinckia lycopsoides (tarweed fiddleneck)	4	--
Chaenactis douglassi (hoary falseyarrow)	4	--
Erigeron filifolius (threadleaf fleabane)	4	16
Linum perenne (wild blueflax)	12	4
*Lepidium perfoliatum** (clasping pepperweed)	8	--
Lupinus sulphurous (sulfur lupine)	24	80
*Tragopogon dubius** (yellow salsify)	8	12
Machaeranthera canescens (hoary aster)	32	4
Holosteum umbellatum (jagged chickweed)	76	16
Draba verna (spring whitlow)	--	16
Agoseris grandiflora (mountain dandelion)	4	--
Chrysothamnus nauseosus (gray rabbitbrush)	12	--
Chrysothamnus viscidiflorus (green rabbitbrush)	4	--
Bare soil	80	48
Biotic crust	40	100

* Introduced species.

Table A-6. Percent Canopy Cover on Bridge Overlook Sites in 1998.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	24.4	50.1
*Salsola kali** (Russian thistle)	2.5	0.7
Ambrosia acanthicarpa (bur ragweed)	0.5	0.1
Psoralea lanceolata (dune scurfpea)	13.6	0.6
Stipa comata (needle-and-thread grass)	0.5	X
Gilia leptomeria (great basin gilia)	11.3	8.5
Mentzelia albicaulis (whitestem stickleaf)	0.1	--
Oenothera pallida (pale evening primrose)	X	1.2
Descurainia sp. (tansymustard)	7	3.4
Cryptantha circumscissa (matted cryptantha)	0.6	0.4
Eriogonum niveum (snow buckwheat)	0.6	3.9
Artemisia tridentata (big sagebrush)	X	16.3
Purshia tridentata (antelope bitterbrush)	X	2.5
Chrysothamnus viscidiflorus (green rabbitbrush)	--	X
Grayia spinosa (spiny hopsage)	--	7.4
Oryzopsis hymenoides (Indian ricegrass)	X	X
Festuca octoflora (six-weeks fescue)	0.4	0.5
Cymopterus terebinthinus (turpentine parsley)	X	2.5
Layia glandulosa (white-daisy tidytips)	0.1	0.1
Comandra umbellata (bastard toadflax)	--	2.9
Amsinckia lycopsoides (tarweed fiddleneck)	X	X
Microsteris gracilis (annual phlox)	0.1	--
Poa scabrella (pine bluegrass)	X	X
Sitanion hystrix (bottlebrush squirreltail)	X	--
Chrysothamnus nauseosus (gray rabbitbrush)	X	--
Abronia mellifera (white sandverbena)	X	--
Balsamorhiza careyana (Carey's balsamroot)	--	X
Erysimum asperum (rough wallflower)	--	X
Tragopogon dubius (yellow salsify)		X
Poa sandbergii (Sandberg's bluegrass)	--	X
Biotic crust	1.5	29.1
Bare soil	58.4	31.4
Total (does not include crust or soil)	**61.7**	**101.1**

* Introduced species.

X = Present but not counted in plot frames.

Table A-7. Percent Frequency of Occurrence on Bridge Overlook Sites in 1998.

Species	Waste Site	Control Site
*Bromus tectorum** (cheatgrass)	80	92
*Salsola kali** (Russian thistle)	80	28
Ambrosia acanthicarpa (bur ragweed)	20	4
Psoralea lanceolata (dune scurfpea)	52	4
Stipa comata (needle-and-thread grass)	20	--
Gilia leptomeria (great basin gilia)	72	52
Mentzelia albicaulis (whitestem stickleaf)	4	--
Oenothera pallida (pale evening primrose)	--	8
Descurainia sp. (tansymustard)	48	40
Cryptantha circumscissa (matted cryptantha)	4	16
Eriogonum niveum (snow buckwheat)	4	20
Artemisia tridentata (big sagebrush)	--	24
Purshia tridentata (antelope bitterbrush)	--	4
Grayia spinosa (spiny hopsage)	--	12
Festuca octoflora (six-weeks fescue)	16	20
Cymopterus terebinthinus (turpentine parsley)	--	4
Layia glandulosa (white-daisy tidytips)	4	4
Comandra umbellata (bastard toadflax)	--	20
Microsteris gracilis (annual phlox)	4	--
Biotic crust	4	88
Bare soil	100	80

* Introduced species.

Table A-8. Percent Canopy Cover at PSN 72/82 Well Mound Sites in 1998.

Species	Waste Site	Road	Control Site
*Bromus tectorum** (cheatgrass)	29.5	26.7	43.5
*Salsola kali** (Russian thistle)	0.6	0.2	0.1
Ambrosia acanthicarpa (bur ragweed)	1.4	2.9	0.3
Oenothera pallida (pale evening primrose)	1.5	0.6	0.2
Artemisia tridentata (big sagebrush)	7.3	3.2	13.2
Chrysothamnus nauseosus (gray rabbitbrush)	3.0	0.1	--
Grayia spinosa (spiny hopsage)	0.1	--	1.5
Koeleria cristata (prairie junegrass)	0.1	--	--
Poa sandbergii (Sandberg's bluegrass)	1.3	0.1	3.2
*Poa bulbosa** (bulbous bluegrass)	0.1	0.3	--
Poa scabrella (pine bluegrass)	0.1	--	--
Sitanion hystrix (bottlebrush squirreltail)	1.3	--	--
Stipa comata (needle-and-thread grass)	5.1	0.1	--
Festuca octoflora (six-weeks fescue)	5.6	6.6	1.7
Microsteris gracilis (annual phlox)	1.3	1.4	0.3
Holosteum umbellatum (jagged chickweed)	4.5	3.8	1.9
Draba verna (spring whitlow)	2.4	7	3.5
Rumex venosus (winged dock)	--	--	0.7
*Lactuca serriola** (prickly lettuce)	--	--	0.1
Amsinckia tessellata (devil's lettuce)	0.4	0.2	0.3
Amsinckia lycopsoides (tarweed fiddleneck)	0.3	0.3	0.3
*Sisymbrium altissimum** (tumblemustard)	0.5	0.3	--
Descurainia spp (tansymustard)	1.5	0.2	0.9
*Erodium cicutarium** (storksbill)	4.5	3.2	--
Balsamorhiza careyana (Carey's balsamroot)	0.7	0.3	3.6
Comandra umbellata (bastard toadflax)	0.2	--	--
Machaeranthera canescens (hoary aster)	3.8	6.4	1
Cryptantha circumscissa (matted cryptantha)	--	1.1	--
Eriogonum niveum (snow buckwheat)	--	0.8	--
*Tragopogon dubius** (yellow salsify)	--	0.1	--
Plantago patagonica (Indian wheat)	--	0.8	--
Biotic crust	0.6	--	8.4
Bare soil	90.3	81.3	42.3
Litter	7.8	9.6	35.7
Total (does not include crust , soil, or litter)	**77.1**	**66.7**	**76.3**

* Introduced species.

X = Present but not counted in plot frames.

Table A-9. Percent Frequency of Occurrence at PSN 72/82 Well Mound Sites in 1998.

Species	Waste Site	Road	Control Site
*Bromus tectorum** (cheatgrass)	96	96	84
*Salsola kali** (Russian thistle)	24	8	4
Ambrosia acanthicarpa (bur ragweed)	56	56	12
Oenothera pallida (pale evening primrose)	20	4	8
Artemisia tridentata (big sagebrush)	28	28	36
Chrysothamnus nauseosus (gray rabbitbrush)	8	4	--
Grayia spinosa (spiny hopsage)	4	--	4
Koeleria cristata (prairie junegrass)	4	--	--
Poa sandbergii (Sandberg's bluegrass)	12	4	28
*Poa bulbosa** (bulbous bluegrass)	4	12	--
Poa scabrella (pine bluegrass)	4	--	--
Sitanion hystrix (bottlebrush squirreltail)	12	--	--
Stipa comata (needle-and-thread grass)	48	4	--
Festuca octoflora (six-weeks fescue)	32	68	28
Microsteris gracilis (annual phlox)	52	36	12
Holosteum umbellatum (jagged chickweed)	84	72	36
Draba verna (spring whitlow)	76	68	24
Rumex venosus (winged dock)	--	--	8
*Lactuca serriola** (prickly lettuce)	--	--	4
Amsinckia tessellata (devil's lettuce)	16	8	12
Amsinckia lycopsoides (tarweed fiddleneck)	12	12	12
*Sisymbrium altissimum** (tumblemustard)	20	12	--
Descurainia sp (tansymustard)	40	8	36
*Erodium cicutarium** (storksbill)	64	48	--
Balsamorhiza careyana (Carey's balsamroot)	8	12	12
Comandra umbellata (bastard toadflax)	8	--	--
Machaeranthera canescens (hoary aster)	36	44	20
Cryptantha circumscissa (matted cryptantha)	--	24	--
Eriogonum niveum (snow buckwheat)	--	12	--
*Tragopogon dubius** (yellow salsify)	--	4	--
Plantago patagonica (Indian wheat)	--	32	--
Biotic crust	4	--	52
Bare soil	100	96	80
Litter	100	72	96

* Introduced species.

Table A-10. Percent Canopy Cover for PSN 12/14 in 1998.

Species	Control	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	46.6	21.6	26.8	42.5	28.5	45.2
Ambrosia acanthicarpa (bur ragweed)	0.6	0.4	7.6	2.0	4.0	3.5
*Sisymbrium altissimum** (tumblemustard)	0.7	0.4	21.3	0.5	16.5	0.3
*Salsola kali** (Russian thistle)	0.3	1.9	4.4	0.5	2.0	1.2
Artemisia tridentata (big sagebrush)	9.4	0.6	3.9	X	8.5	1.6
Purshia tridentata (antelope bitterbrush)	3.9	--	--	--	--	--
Chrysothamnus viscidiflorus (green rabbitbrush)	1.7	--	--	--	--	0.1
Chrysothamnus nauseosus (gray rabbitbrush)	--	--	--	--	--	0.2
Poa sandbergii (Sandberg's bluegrass)	7.7	--	16	11	0.5	0.2
*Poa bulbosa** (bulbous bluegrass)	--	--	--	--	--	0.2
Stipa comata (needle-and-thread grass)	--	7.6	7.5	30.5	3.5	--
Oryzopsis hymenoides (Indian ricegrass)	0.1	5.4	--	--	--	X
Agropyron dasytachyum (thickspike wheatgrass)	--	5.0	--	--	--	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	--	--	0.5	--	0.1
Cymopterus terebinthinus (turpentine parsley)	4.8	--	--	--	--	--
Descurainia pinnata (tansymustard)	--	0.1	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	0.2	0.9	--	1.5	1.3
Eriogonum niveum (snow buckwheat)	1.6	--	0.1	--	--	0.9
Festuca octoflora (six weeks fescue)	--	--	--	--	--	0.9
Holosteum umbellatum (jagged chickweed)	16.3	0.6	6.3	15.5	26.5	3.3
Draba verna (spring whitlow)	13.5	--	--	--	--	0.7
*Lactuca serriola** (prickly lettuce)	--	--	2.3	--	2.5	0.4
Machaeranthera canescens (hoary aster)	0.2	--	0.3	0.5	--	0.1
Microsteris gracilis (annual phlox)	1.6	--	--	6.5	--	2.6
Oenothera pallida (pale evening primrose)	0.9	3.0	0.1	3.0	0.5	X
Phlox longifolia (longleaf phlox)	1.3	--	--	--	--	--
Comandra umbellatum (bastard toadflax)	0.8	--	--	--	--	--
Achillea millefolium (yarrow)	0.7	0.1	0.3	--	--	X
*Tragopogon dubius** (yellow salsify)	--	--	0.1	--	--	X
Psoralea lanceolata (dune scurfpea)	--	--	--	20	--	--
Balsamorhiza careyana (Carey's balsamroot)	--	--	--	--	--	0.1
Lappula redowskii (Western stickseed)	--	--	--	--	--	X
Plantago patagonica (Indian wheat)	--	--	--	--	--	X
Poa scabrella (pine bluegrass)	--	X	--	--	--	--
Koeleria cristata (prairie junegrass)	--	X	--	--	--	--
Phacelia linearis (threadleaf scorpionweed)	--	--	--	--	--	X
Brodiaea douglasii (Douglas' clusterlily)	--	--	--	--	--	X
biotic crust	36.3	--	8.5	0.5	7.5	--
bare soil	40.3	78.8	32.5	40.5	54	60.9
Litter	37.6	14.1	58.1	57.5	59.5	5.4
Total cover (not including crust, bare soil, or litter)	**112.7**	**46.9**	**97.9**	**133**	**94.5**	**62.9**

* Introduced species.

X = Present but not counted in plot frames.

Table A-11. Percent Frequency of Occurrence on PSN 12/14 Sites in 1998.

Species	Control	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	100	100	95	100	100	100
Ambrosia acanthicarpa (bur ragweed)	24	16	70	80	60	60
*Sisymbrium altissimum** (tumblemustard)	28	16	70	20	80	12
*Salsola kali** (Russian thistle)	12	76	30	20	80	48
Artemisia tridentata (big sagebrush)	16	4	10	--	60	8
Purshia tridentata (antelope bitterbrush)	4	--	--	--	--	--
Chrysothamnus viscidiflorus (green rabbitbrush)	12	--	--	--	--	4
Chrysothamnus nauseosus (gray rabbitbrush)	--	--	--	--	--	8
Poa sandbergii (Sandberg's bluegrass)	60	--	45	60	20	8
*Poa bulbosa** (bulbous bluegrass)	--	--	--	--	--	8
Stipa comata (needle-and-thread grass)	--	56	40	80	40	--
Oryzopsis hymenoides (Indian ricegrass)	4	28	--	--	--	--
Agropyron dasytachyum (thickspike wheatgrass)	--	8	--	--	--	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	--	--	20	--	4
Cymopterus terebinthinus (turpentine parsley)	36	--	--	--	--	--
Descurainia pinnata (tansymustard)	--	4	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	8	35	--	60	32
Eriogonum niveum (snow buckwheat)	8	--	5	--	--	16
Festuca octoflora (six weeks fescue)	--	--	--	--	--	16
Holosteum umbellatum (jagged chickweed)	96	24	55	60	100	72
Draba verna (spring whitlow)	76	--	--	--	--	28
*Lactuca serriola** (prickly lettuce)	--	--	65	--	100	16
Machaeranthera canescens (hoary aster)	8	--	10	20	--	4
Microsteris gracilis (annual phlox)	44	--	--	60	--	44
Oenothera pallida (pale evening primrose)	16	40	5	20	20	--
Phlox longifolia (longleaf phlox)	8	--	--	--	--	--
Comandra umbellatum (bastard toadflax)	12	--	--	--	--	--
Achillea millefolium (yarrow)	8	4	10	--	--	--
*Tragopogon dubius** (yellow salsify)	--	--	5	--	--	--
Psoralea lanceolata (dune scurfpea)	--	--	--	40	--	--
Balsamorhiza careyana (Carey's balsamroot)	--	--	--	--	--	4
biotic crust	84	--	35	20	20	--
bare soil	92	100	95	100	80	96
Litter	100	96	100	100	100	8

* Introduced species.

Table A-12. Percent Canopy Cover and Frequency of Occurrence on 2,4-D Site.

Species	Percent Cover	Percent Frequency
*Bromus tectorum** (Cheatgrass)	34.7	96
*Salsola kali** (Russian thistle)	6.2	56
*Sisymbrium altissimum** (tumblemustard)	1.0	20
Ambrosia acanthicarpa (bur ragweed	0.5	20
Descurainia spp (tansymustard)	0.2	8
Poa sandbergii (Sandberg's Bluegrass)	2.0	40
*Poa bulbosa** (bulbous bluegrass)	0.1	4
Festuca octoflora (six weeks fescue)	0.1	4
Rumex venosus (winged dock)	0.1	4
Lappula redowskii (stickseed)	0.1	4
Amsinckia lycopsoides (tarweed fiddleneck)	0.3	12
Holosteum umbellatum (jagged chickweed)	0.2	8
Draba verna (spring whitlow)	0.3	12
Plantago patagonica (Indian wheat)	0.1	4
Bare soil	81	96
Total Cover	**45.9**	

* Introduced species.

APPENDIX B

1997 MONITORING RESULTS

Table B-1. Percent Canopy Cover on Horn Rapids Landfill for 1997.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	7.5	9.5	10.1	6.4	11.5	11.1
Salsola kali (Russian thistle)	2.2	2.6	1.6	8.6	13.3	1.5
Bromus tectorum (cheatgrass)	6	7.8	5.5	1.6	1.2	22.9
Amsinckia lycopsoides (tarweed)	--	--	--	--	--	0.6
Sisymbrium altissimum (tumblemustard)	0.2	0.1	0.4	0.5	0.9	0.1
Ambrosia acanthicarpa (bur ragweed)	0.2	1.4		0.3	0.4	1.8
Chenopodium sp (lambsquarter)	0.2	0.1	0.3	1.0	1.1	--
Convolvulus arvensis (field bindweed)	--	--	--	0.2	--	--
Holosteum umbellatum (jagged chickweed)	4.0	4.8	2.3	0.9	0.3	0.4
Lactuca serriola (prickly lettuce)	0.2	0.3	0.3	--	--	--
Draba verna (spring whitlow)	0.2	2.9	2.1	0.6	1.1	0.2
Medicago sativa (alfalfa)	--	0.1	--	--	--	--
Descurainia pinnata (tansymustard)	0.1	0.3	0.2	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	0.2	0.2	--	--
Poa sandbergii (Sandberg's bluegrass)	--	--	0.1	--	--	--
Plantago patagonica (Indian wheat)	--	--	--	0.2	--	--
Erodium cicutarium (storksbill)	--	--	--	0.2	0.1	0.2
Agastache occidentalis (western horsemint)	--	--	--	0.2	--	--
Tragopogon dubius (yellow salsify)	0.8	0.1	--	--	--	--
Cardaria draba * (whitetop)	--	--	--	--	3 plants	--
Total	**21.6**	**30**	**23.1**	**20.9**	**29.9**	**38.8**

* Not counted in plot frames.

Table B-2. Percent Frequency of Occurrence on Horn Rapids Landfill for 1997.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	80	92	84	100	92	80
Salsola kali (Russian thistle)	68	84	64	96	96	40
Bromus tectorum (cheatgrass)	84	80	80	64	48	96
Amsinckia lycopsoides (tarweed)	--	--	--	--	--	4
Sisymbrium altissimum (tumblemustard)	8	4	16	20	36	4
Ambrosia acanthicarpa (bur ragweed)	8	36	--	12	16	52
Chenopodium sp (lambsquarter)	8	4	12	40	44	--
Convolvulus arvensis (field bindweed)	--	--	--	8	--	--
Holosteum umbellatum (jagged chickweed)	80	72	52	16	12	16
Lactuca serriola (prickly lettuce)	8	12	12	--	--	--
Draba verna (spring whitlow)	8	40	44	24	44	8
Medicago sativa (alfalfa)	--	4	--	--	--	--
Descurainia pinnata (tansymustard)	4	12	8	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	8	8	--	--
Poa sandbergii (Sandberg's bluegrass)	--	--	4	--	--	--
Plantago patagonica (Indian wheat)	--	--	--	8	--	--
Erodium cicutarium (storksbill)	--	--	--	8	4	8
Agastache occidentalis (western horsemint)	--	--	--	8	--	--
Tragopogon dubius (yellow salsify)	12	4	--	--	--	--

Table B-3. Percent Canopy Cover on the Horseshoe Landfill in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	36.1	25
Artemisia tridentata (big sagebrush)	5.5	10.1
Agropyron spicatum (bluebunch wheatgrass)	0.9	2.5
Poa sandbergii (Sandberg's bluegrass)	2.4	51.4
Sitanion hystrix (bottlebrush squirreltail)	1.1	--
Stipa comata (needle-and-thread grass)	--	0.1
*Poa bulbosa** (bulbous bluegrass)	0.1	--
Festuca octoflora (sixweeks fescue)	0.2	--
Oryzopsis hymenoides (Indian ricegrass)	0.1	0.1
*Sisymbrium altissimum** (tumblemustard)	2.2	0.1
*Melilotis officinalis** (sweet clover)	1.6	--
Epilobium paniculatum (tall willowherb)	1.6	0.1
*Lactuca serriola** (prickly lettuce)	1.8	--
Crepis atrabarba (slender hawksbeard)	0.7	4.7
*Kochia scoparia** (red belvedere)	0.1	--
*Salsola kali** (Russian thistle)	0.1	--
Descurainia sp (tansymustard)	0.2	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	0.1
Chaenactis douglasii (hoary falseyarrow)	0.1	0.2
Erigeron filifolius (threadleaf fleabane)	0.8	1.2
Linum perenne (wild blueflax)	--	0.1
*Lepidium perfoliatum** (clasping pepperweed)	0.1	--
Lupinus sulphurous (sulfur lupine)	0.3	13.5
*Tragopogon dubius** (yellow salsify	--	0.5
Balsamorhiza careyana (Carey's balsamroot)	--	0.1
Machaeranthera canescens (hoary aster)	2.0	--
Biotic crust	--	88.3
Total (biotic crust not included)	**58**	**109.8**

* Introduced species.

Table B-4. Percent Frequency of Occurrence on the Horseshoe Landfill in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	88	84
Artemisia tridentata (big sagebrush)	64	60
Agropyron spicatum (bluebunch wheatgrass)	36	4
Poa sandbergii (Sandberg's bluegrass)	56	92
Sitanion hystrix (bottlebrush squirreltail)	24	--
Stipa comata (needle-and-thread grass)	--	4
*Poa bulbosa** (bulbous bluegrass)	4	--
Festuca octoflora (sixweeks fescue)	8	--
Oryzopsis hymenoides (Indian ricegrass)	4	4
*Sisymbrium altissimum** (tumblemustard)	48	4
*Melilotis officinalis** (sweet clover)	64	--
Epilobium paniculatum (tall willowherb)	64	4
*Lactuca serriola** (prickly lettuce)	52	--
Crepis atrabarba (slender hawksbeard)	8	68
*Kochia scoparia** (red belvedere)	4	--
*Salsola kali** (Russian thistle)	4	--
Descurainia sp (tansymustard)	8	--
Amsinckia lycopsoides (tarweed fiddleneck)	--	4
Chaenactis douglasii (hoary falseyarrow)	4	8
Erigeron filifolius (threadleaf fleabane)	12	28
Linum perenne (wild blueflax)	--	4
*Lepidium perfoliatum** (clasping pepperweed)	4	--
Lupinus sulphurous (sulfur lupine)	12	76
*Tragopogon dubius** (yellow salsify	--	20
Balsamorhiza careyana (Carey's balsamroot)	--	4
Machaeranthera canescens (hoary aster)	40	--
Biotic crust	--	96

* Introduced species.

Table B-5. Percent Canopy Cover on Bridge Overlook Sites in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	5.8	32.4
*Salsola kali** (Russian thistle)	1.4	0.2
Ambrosia acanthicarpa (bur ragweed)	1.8	0.6
Psoralea lanceolata (dune scurfpea)	1.4	1.2
Koeleria cristata (prairie junegrass)	0.1	--
Stipa comata (needle-and-thread grass)	0.7	--
Gilia leptomeria (great basin gilia)	0.2	0.2
Mentzelia albicaulis (whitestem stickleaf)	0.2	--
Oenothera pallida (pale evening primrose)	0.1	0.1
Descurainia sp. (tansymustard)	1.7	--
Cryptantha circumscissa (matted cryptantha)	0.1	0.2
Eriogonum niveum (snow buckwheat)	--	12.1
Artemisia tridentata (big sagebrush)	--	4.2
Purshia tridentata (antelope bitterbrush)	--	6.5
Chrysothamnus viscidiflorus (gray rabbitbrush)	--	1.5
Grayia spinosa (spiny hopsage)	X	3.5
Oryzopsis hymenoides (Indian ricegrass)	X	1.5
Festuca octoflora (six-weeks fescue)	--	0.1
Cymopterus terebinthinus (spring turpentine parsley)	X	0.6
Layia glandulosa (white-daisy tidytips)	--	0.1
Comandra umbellata (bastard toadflax)	--	0.9
Amsinckia lycopsoides (tarweed fiddleneck)	X	0.1
Biotic crust	--	21.8
Total (biotic crust not included)	**13.5**	**66**

* Introduced species.

X = Present but not counted in plot frames.

Table B-6. Percent Frequency of Occurrence on Bridge Overlook Sites in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	60	84
*Salsola kali** (Russian thistle)	36	8
Ambrosia acanthicarpa (bur ragweed)	32	24
Psoralea lanceolata (dune scurfpea)	16	8
Koeleria cristata (prairie junegrass)	4	--
Stipa comata (needle-and-thread grass)	8	--
Gilia leptomeria (great basin gilia)	8	8
Mentzelia albicaulis (whitestem stickleaf)	8	--
Oenothera pallida (pale evening primrose)	4	4
Descurainia sp. (tansymustard)	12	--
Cryptantha circumscissa (matted cryptantha)	4	8
Eriogonum niveum (snow buckwheat)	--	28
Artemisia tridentata (big sagebrush)	--	16
Purshia tridentata (antelope bitterbrush)	--	12
Chrysothamnus viscidiflorus (gray rabbitbrush)	--	4
Grayia spinosa (spiny hopsage)	--	8
Oryzopsis hymenoides (Indian ricegrass)	--	4
Festuca octoflora (six-weeks fescue)	--	4
Cymopterus terebinthinus (turpentine parsley)	--	4
Layia glandulosa (white-daisy tidytips)	--	4
Comandra umbellata (bastard toadflax)	--	16
Amsinckia lycopsoides (tarweed fiddleneck)	--	4
Biotic crust	--	56

* Introduced species.

Table B-7. Percent Canopy Cover at PSN 72/82 Well Mound Sites in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	23.1	40.8
*Salsola kali** (Russian thistle)	2.5	6.4
Ambrosia acanthicarpa (bur ragweed)	2.0	0.1
Oenothera pallida (pale evening primrose)	0.5	0.1
Artemisia tridentata (big sagebrush)	3.6	16
Chrysothamnus nauseosus (gray rabbitbrush)	0.1	0.6
Grayia spinosa (spiny hopsage)	--	1.5
Koeleria cristata (prairie junegrass)	0.1	--
Oryzopsis hymenoides (Indian ricegrass)	0.3	--
Poa sandbergii (Sandberg's bluegrass)	0.2	--
Sitanion hystrix (bottlebrush squirreltail)	0.1	--
Stipa comata (needle-and-thread grass)	0.5	--
Amsinckia tessellata (devil's lettuce)	0.2	0.1
*Sisymbrium altissimum** (tumblemustard)	0.5	0.1
Descurainia pinnata (tansymustard)	0.3	1.4
Fritillaria pudica (yellowbell)	0.1	0.8
Erodium cicutarium (storksbill)	0.1	0.2
Balsamorhiza careyana (Carey's balsamroot)	--	0.8
Comandra umbellata (bastard toadflax)	--	0.6
Machaeranthera canescens (hoary aster)	--	0.1
Biotic crust	0.1	29.4
Total cover (biotic crust not included)	**34.2**	**69.6**

* Introduced species.

Table B-8. Percent Frequency of Occurrence at PSN 72/82 Well Mound Sites in 1997.

Species	Waste Site	Reference Site
*Bromus tectorum** (cheatgrass)	88	96
*Salsola kali** (Russian thistle)	80	28
Ambrosia acanthicarpa (bur ragweed)	80	4
Oenothera pallida (pale evening primrose)	20	4
Artemisia tridentata (big sagebrush)	28	52
Chrysothamnus nauseosus (gray rabbitbrush)	4	4
Grayia spinosa (spiny hopsage)	--	4
Koeleria cristata (prairie junegrass)	4	--
Oryzopsis hymenoides (Indian ricegrass)	12	--
Poa sandbergii (Sandberg's bluegrass)	8	--
Sitanion hystrix (bottlebrush squirreltail)	4	--
Stipa comata (needle-and-thread grass)	20	--
Amsinckia tessellata (devil's lettuce)	8	4
*Sisymbrium altissimum** (tumblemustard)	20	4
Descurainia pinnata (tansymustard)	12	36
Fritillaria pudica (yellowbell)	4	32
Erodium cicutarium (storksbill)	4	8
Balsamorhiza careyana (Carey's balsamroot)	--	12
Comandra umbellata (bastard toadflax)	--	4
Machaeranthera canescens (hoary aster)	--	4
Biotic crust	4	72

* Introduced species.

Table B-9. Percent Canopy Cover for PSN 12/14 in 1997.

Species	Reference	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	52.3	13.7	42.9	14.5	56.5	32.3
Ambrosia acanthicarpa (bur ragweed)	0.4	3.2	6.0	4.5	0.5	3.4
*Sisymbrium altissimum** (tumblemustard)	0.4	--	16	1.0	1.5	1.1
*Salsola kali** (Russian thistle)	--	0.9	4.0	1.5	2.0	0.7
Artemisia tridentata (big sagebrush)	15.6	--	1.5	0.5	--	--
Purshia tridentata (antelope bitterbrush)	2.1	--	--	--	--	--
Poa sandbergii (Sandberg's bluegrass)	14.6	0.1	0.3	--	--	--
Stipa comata (needle-and-thread grass)	--	6.8	3.0	3.5	3.0	--
Koeleria cristata (prairie junegrass)	--	0.1	--	--	--	--
Amsinckia tessellata (devil's lettuce)	--	--	0.1	--	--	--
Cymopterus terebinthinus (turpentine parsley)	0.7	--	--	--	--	--
Descurainia pinnata (tansymustard)	0.1	0.9	--	--	--	--
Draba verna (spring whitlow)	2.5	--	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	0.3	0.5	1.5	0.1
Eriogonum niveum (snow buckwheat)	--	0.6	--	--	--	--
Festuca octoflora (six weeks fescue)	--	--	--	--	--	0.5
Holosteum umbellatum (jagged chickweed)	0.8	--	--	--	--	0.3
*Lactuca serriola** (prickly lettuce)	--	--	0.8	--	1.0	0.2
Machaeranthera canescens (hoary aster)	--	--	0.3	--	--	--
Microsteris gracilis (annual phlox)	1.1	--	--	--	--	0.3
Oenothera pallida (pale evening primrose)	--	0.2	0.3	3.5	--	--
Phlox longifolia (longleaf phlox)	0.1	--	0.1	--	--	--
Rumex venosus (winged dock)	--	--	--	0.5	--	--
Biotic crust	52.5	--	38.5	--	0.5	--
Bare soil	20.2	86.3	20.9	80.5	30	--
Total cover (not including crust or bare soil)	**90.7**	**26.5**	**75.6**	**30**	**66**	**38.9**

* Introduced species.

Table B-10. Percent Frequency of Occurrence on PSN 12/14 Sites in 1997.

Species	Reference	Plot 5	Plot 4	Plot 2	Plot 1	Road
*Bromus tectorum** (cheatgrass)	100	96	95	100	80	96
Ambrosia acanthicarpa (bur ragweed)	16	88	45	80	20	56
*Sisymbrium altissimum** (tumblemustard)	16	--	70	40	60	24
*Salsola kali** (Russian thistle)	--	36	65	60	80	28
Artemisia tridentata (big sagebrush)	32	--	10	20	--	--
Purshia tridentata (antelope bitterbrush)	8	--	--	--	--	--
Poa sandbergii (Sandberg's bluegrass)	48	4	10	--	--	--
Stipa comata (needle-and-thread grass)	--	56	20	40	20	--
Koeleria cristata (prairie junegrass)	--	4	--	--	--	--
Amsinckia tessellata (devil's lettuce)	--	--	5	--	--	--
Cymopterus terebinthinus (turpentine parsley)	8	--	--	--	--	--
Descurainia pinnata (tansymustard)	4	36	--	--	--	--
Draba verna (spring whitlow)	60	--	--	--	--	--
Epilobium paniculatum (tall willowherb)	--	--	10	20	60	4
Eriogonum niveum (snow buckwheat)	--	4	--	--	--	--
Festuca octoflora (six weeks fescue)	--	--	--	--	--	20
Holosteum umbellatum (jagged chickweed)	12	--	--	--	--	12
*Lactuca serriola** (prickly lettuce)	--	--	30	--	40	8
Machaeranthera canescens (hoary aster)	--	--	10	--	--	--
Microsteris gracilis (annual phlox)	44	--	--	--	--	12
Oenothera pallida (pale evening primrose)	--	8	10	40	--	--
Phlox longifolia (longleaf phlox)	4	--	5	--	--	--
Rumex venosus (winged dock)	--	--	--	20	--	--
Biotic crust	72	--	70	--	20	--
Bare soil	64	100	70	100	60	--

* Introduced species.

APPENDIX C

1996 MONITORING RESULTS FOR HORN RAPIDS LANDFILL AND HORSHOE LANDFILL

Table C-1. Percent Canopy Cover on Horn Rapids Landfill in 1996.

Plant Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	11	5.2	9.3	25.9	12.8	12
Salsola kali (Russian thistle)	22.7	9.8	12.2	6.0	8.4	14.7
Bromus tectorum (cheatgrass)	1.8	1.1	1.7	0.3	0.1	2.8
Amsinckia lycopsoides (tarweed)	0.3	0.6	0.1	0.1	0.3	0.4
Sisymbrium altissimum (tumblemustard)	1.3	0.4	0.1	0.2	0.3	0.4
Triticum sp (wheat)	2.6	0.3	0.7	0	0	5.6
Ambrosia acanthicarpa (bur ragweed)	1.2	0.7	0.1	0.8	0.9	2.0
Chenopodium sp (lambsquarter)	1.0	4.8	2.4	1.7	1.2	0.1
Lactuca serriola (prickly lettuce)	0.1	0.2	0	0.1	0.1	0
Erodium cicutarium (storksbill)	0.2	0	0	0.1	0	0
Total	**41.9**	**23.2**	**26.8**	**35**	**24.2**	**38.1**

Table C-2. Percent Frequency of Occurrence on Horn Rapids Landfill in 1996.

Plant Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Agropyron spp (wheatgrasses)	92	88	100	100	100	92
Salsola kali (Russian thistle)	100	100	100	100	100	100
Bromus tectorum (cheatgrass)	16	24	12	12	4	36
Amsinckia lycopsoides (tarweed)	12	4	4	4	12	16
Sisymbrium altissimum (tumblemustard)	32	16	4	8	12	16
Triticum sp (wheat)	44	12	28	0	0	32
Ambrosia acanthicarpa (bur ragweed)	28	8	4	12	36	60
Chenopodium sp (lambsquarter)	20	76	76	48	28	4
Lactuca serriola (prickly lettuce)	0	4	8	4	4	4
Erodium cicutarium (storksbill)	0	8	0	0	4	0

Table C-3. Percent Canopy Cover on the Horseshoe Landfill in 1996.

Plant Name	Percent Cover
*Melilotis officinalis** (sweet clover)	7.8
*Bromus tectorum** (cheatgrass)	7.2
Artemisia tridentata (big sagebrush)	2.8
Descurainia sp (tansymustard)	2.7
*Sisymbrium altissimum** (tumblemustard)	2.1
Epilobium paniculatum (tall willowherb)	1.2
Agropyron spicatum (bluebunch wheatgrass)	1.1
Crepis atrabarba (slender hawksbeard)	1.0
Lupinus sulphurous (sulfur lupine)	0.7
Erigeron filifolius (threadleaf fleabane)	0.7
Linum perenne (wild blueflax)	0.7
*Lactuca serriola** (prickly lettuce)	0.6
*Salsola kali** (Russian thistle)	0.5
*Kochia scoparia** (red belvedere)	0.5
Poa sandbergii (Sandberg's bluegrass)	0.3
Sitanion hystrix (bottlebrush squirreltail)	0.3
*Lepidium perfoliatum** (clasping pepperweed)	0.2
Chenopodium leptophyllum (slimleaf goosefoot)	0.2
Amsinckia lycopsoides (tarweed fiddleneck)	0.2
Chaenactis douglasii (hoary falseyarrow)	0.2
Machaeranthera canescens (hoary aster)	0.2
Ambrosia acanthicarpa (bur ragweed)	0.1
Chrysothamnus nauseosus (gray rabbitbrush)	0.1
Total	**31.4**

* Introduced species.

Table C-4. Percent Frequency of Occurrence on the Horseshoe Landfill in 1996.

Plant Name	Percent Frequency
*Bromus tectorum** (cheatgrass)	92
Artemisia tridentata (big sagebrush)	52
Agropyron spicatum (bluebunch wheatgrass)	44
*Sisymbrium altissimum** (tumblemustard)	44
*Melilotis officinalis** (sweet clover)	40
Epilobium paniculatum (tall willowherb)	28
*Lactuca serriola** (prickly lettuce)	24
Crepis atrabarba (slender hawksbeard)	20
*Kochia scoparia** (red belvedere)	20
*Salsola kali** (Russian thistle)	20
Descurainia sp (tansymustard)	12
Poa sandbergii (Sandberg's bluegrass)	12
Sitanion hystrix (bottlebrush squirrel)	12
Amsinckia lycopsoides (tarweed fiddleneck)	8
Chaenactis douglasii (hoary falseyarrow)	8
Chenopodium leptophyllum (slimleaf goosefoot)	8
Erigeron filifolius (threadleaf fleabane)	8
*Lepidium perfoliatum** (clasping pepperweed)	8
Linum perenne (wild blueflax)	8
Lupinus sulphurous (sulfur lupine)	8
Machaeranthera canescens (hoary aster)	8
Ambrosia acanthicarpa (bur ragweed)	4
Chrysothamnus nauseosus (gray rabbitbrush)	4

* Introduced species.

APPENDIX D

NAME CHANGES INCLUDED IN INTEGRATED TAXONOMIC INFORMATION SYSTEM

Name changes included in Integrated Taxonomic Information System (ITIS 1998).

Recent name changes for species mentioned in this report. The first name is that used in Hitchcock and Cronquist (1973) and the second is the more recent version.

Agropyron spicatum = *Pseudoroegneria spicata ssp. spicata*
Chrysothamnus nauseosus = *Ericameria nauseosa* ssp. *nauseosa* var. *nauseosa*
Cymopterus terebinthinus = *Pteryxia terebinthina* var. *terebinthina*
Epilobium paniculatum = *Epilobium brachycarpum*
Festuca octoflora = *Vulpia octoflora* var. *octoflora*
Koeleria cristata = *Koeleria macrantha*
Microsteris gracilis = *Phlox gracilis* ssp. *gracilis*
Oryzopsis hymenoides = *Achnatherum hymenoides*
Poa sandbergii = *Poa secunda*
Psoralea lanceolata = *Psoralidium lanceolatum*
Sitanion hystrix = *Elymus elymoides* ssp. *elymoides*
Stipa comata = *Hesperostipa comata* ssp. *comata*

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